PIER DISTRIBUTED ENERGY RESOURCES INTEGRATION RESEARCH PROGRAM

RESEARCH AND DEVELOPMENT PLAN

STAFF REPORT

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Preface

The Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The PIER Program, managed by the California Energy Commission (Commission), annually awards up to $62 million to conduct the most promising public interest energy research by partnering with Research, Development, and Demonstration (RD&D) organizations, including individuals, businesses, utilities, and public or private research institutions.

PIER funding efforts are focused on the following six RD&D program areas:

- Buildings End-Use Energy Efficiency
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy
- Environmentally-Preferred Advanced Generation
- Energy-Related Environmental Research
- Energy Systems Integration

What follows is the Research and Development Plan for the PIER Distributed Energy Resources Integration Research Program conducted by the Commission staff.

The report is entitled "PIER Distributed Energy Resources Integration Research Program: Research and Development Plan." This project contributes to the Energy Systems Integration Program.

For more information on the PIER Program, please visit the Commission's Web site at: http://www.energy.ca.gov/research/index.html or contact the Commission's Publications Unit at 916-654-5200.

Executive Summary

The Distributed Energy Resources (DER) Integration R&D Plan is intended to serve as a living document to aid the California Energy Commission's (CEC) program managers in identifying and seizing upon the most appropriate and timely opportunities to further the advancement of DER as a viable energy tool in California given the work already accomplished and insights obtained.

California Energy Commission DG Strategic Plan

In June 2002, the California Energy Commission adopted a Distributed Generation (DG) Strategic Plan policy statement. The DER Integration Research Program (Program) is doing its part, along with the Renewables Program, Efficiency Division, and Commission policy oversight to help achieve the goals laid out. In translating some of the DG Strategic Plan's policy goals into actionable research activities, the research activities of the Program are addressing these goals, wholly or in part (Figure 1).

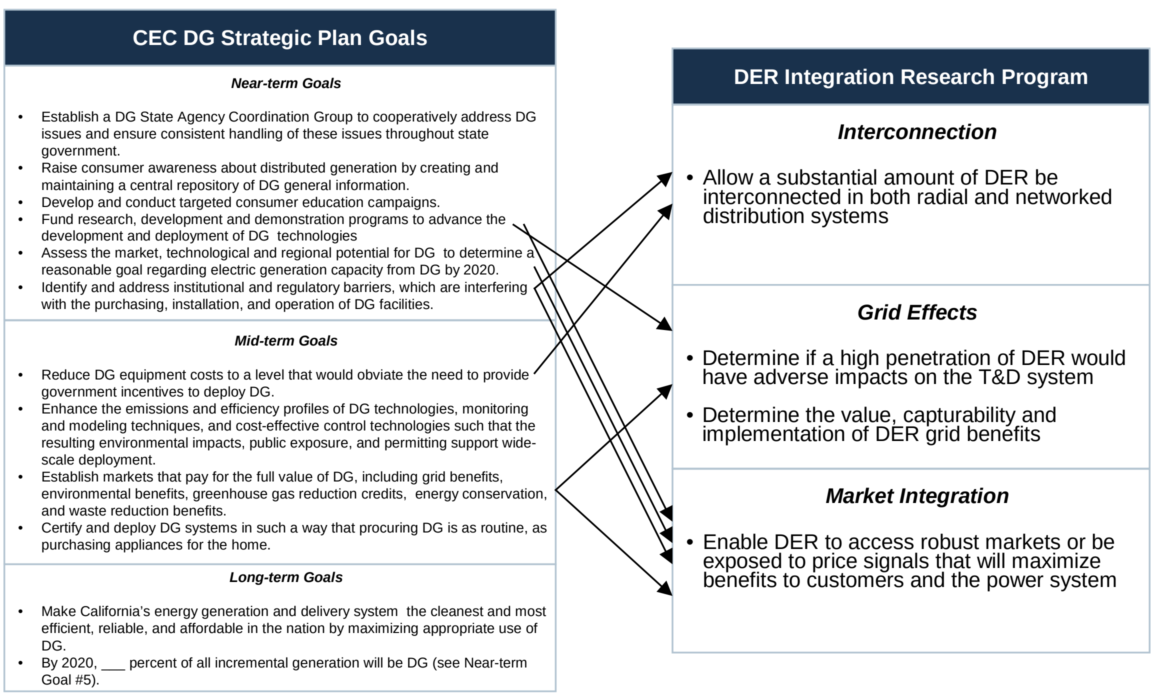

Figure 1: DER Integration R&D Program Support for DG Strategic Plan

DER Integration R&D Planning Process

The DER Integration Research Program is pursuing DER research through a clearly articulated R&D planning process (Figure 2). An iterative feedback loop embedded in the planning process ensures the Program remains current and relevant, able to respond effectively to changes in the industry's technological and commercial environment.

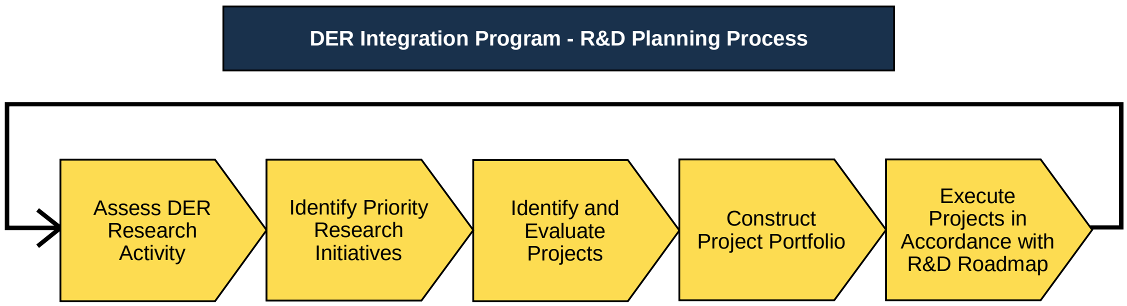

Figure 2: R&D Planning Process

Assess DER Research Activity

In 2001, significant developments in DER technology and the marketplace required a fresh analysis of the DER landscape to identify key challenges appropriate for public interest research. A research assessment was performed to help shape the Program's research efforts in the focus areas of Interconnection, Grid Effects, and Market Integration. The key question this effort was trying to address was "are there research development, demonstration or commercialization opportunities that will make DER a significant resource in California's power system?" There were also critical questions relating to each of the focus areas:

- *Interconnection* – Can a substantial amount of DER be interconnected in both radial and networked distributed systems?
- *Grid Effects* – Would a high penetration of DER have adverse and/or positive effects on the T&D system?
- *Market Integration* – Can DER access robust markets or be exposed to price signals that will maximize benefits to customers and the power system?

The research assessment documented a major step in the research plan development process – to understand current research being conducted by industry, nonprofit organizations and government, and to identify where gaps exist.

A framework was created for assessing the status of the DER research efforts. *Issues* are the critical questions facing the development of DER in the areas of interest. These issues have driven, or will drive, the creation of *research initiatives* to address these questions. Current and potential *projects*, in each of the three areas, are pursuing these research initiatives. There are also crosscutting projects that are addressing issues in more than one area. Each project/activity identified can be mapped to the appropriate research initiative and issue. From the information obtained, the following observations were drawn:

- Challenges involved with interconnection have just begun to be addressed.
- Research to better understanding the negative impact of DER on the grid needs to be balanced with efforts to better understand the benefits that DER may have on the grid.
- Microgrids are emerging as an important area with DER. However, there is not a common definition of the microgrid concept. In addition, details of how a microgrid is

to be effectively operated and controlled to bring about meaningful benefits is still far from clear.

- A lack of a clear successful business model will continue to prevent DER from making a breakthrough into the electricity industry.
- DER integration, optimization and operation are vital to realizing a large penetration of DER. However, understanding the requirements for integration, optimization and operation may not be possible until a clear business model emerges.
- Regulations and policies need to keep pace with and reflect new information and understanding of DER. In many instances, technology is available but deployment is constrained by current policy.
- Significant gaps exist in Interconnection, Grid Effects, and Market Integration research activity where DER Integration Research Program funding can make a dramatic impact.

Identify Priority Research Initiatives

From the DER research assessment, a strong need was observed for a viable business model for the DER industry. This was deemed critical to developing DER as a viable tool in the electricity infrastructure. The effort began by examining the elements of a successful business model, driven by customer needs, technology and infrastructure, and rules and regulations. A business model defines how a company makes money and must factor in the following considerations:

- Value proposition
- Market segment
- Value chain
- Cost structure and profit potential
- Supplier/customer linkages
- Competitive strategy

Business models work together in a value network that supports a value proposition to the customer. For DER then, a value network is a group business models that interact to support a value proposition to a “DER user” market segment.

To determine each value network’s attractiveness to the DER Integration Research Program, a technical market analysis was performed to identify those value networks that would have the greatest impact, the value networks’ fit with the California Energy Commission’s research objectives was determined, and the feasibility of bringing the value networks into being was analyzed. After characterizing, identifying, and determining their attractiveness, the results of the value network analysis were combined with that from the research assessment to help the Program prioritize research initiatives.

In all, fourteen research initiatives from across the different focus areas were identified as high priority, based on their relative research gap size and importance. Promising research is already in the pipeline. DER Integration Research Program activities currently include a portfolio of 10 projects with a total estimated budget requirement of over $6 million for the lifetime of these projects.

Potential projects were scoped to address the high priority initiatives identified in the value network analysis. In addition to addressing the research initiatives, the proposed projects also have linkages to many other CEC activities. The proposed projects were reviewed and characterized to simplify the project selection process.

The Value Metrics Tool was developed to further complement the DER Integration Research Program's previous decision-making process by allowing program managers to better evaluate project proposals. It allows the Program Advisory Committee, comprised of external DER research stakeholders, to make portfolio recommendations considering the value generated by each project. The tool identifies the candidate projects that generate the most value while providing more structure to RFPs and proposal evaluation. Additionally, the Value Metrics Tool assesses the impact of external (e.g., regulatory, market and technology) and internal (e.g., budget) changes. Characteristics measured by the Value Metrics Tool were based on the objectives of the Program.

Construct Project Portfolio

Developing a project portfolio that balances the many goals of the DER Integration Research Program given an environment with uncertain funding can be a significant challenge. To help address this concern, portfolio analysis plotting tools were introduced where projects can be visually presented on axes displaying metrics and characteristics. These visual tools provide snapshots of projects that allow program managers to evaluate whether or not appropriate balance is being maintained against the critical project characteristics as new projects are added or taken away.

Apply Projects to R&D Roadmap

The R&D roadmap (Figure 3) offers a more concrete pathway toward achieving the vision outlined in the California Energy Commission's Distributed Generation Strategic Plan. Careful thought was given to the expected schedule of activities and the timing of outside events that would have an impact on the different focus areas, within the DER Integration Research Program. The roadmap balances these complex factors and plots out a course for short, medium, and long-term action in order to reach the vision for DG in 2020. The current and planned projects are mapped against the roadmap to ensure that momentum is maintained to move toward the vision laid out by the Commission's DG Strategic Plan.

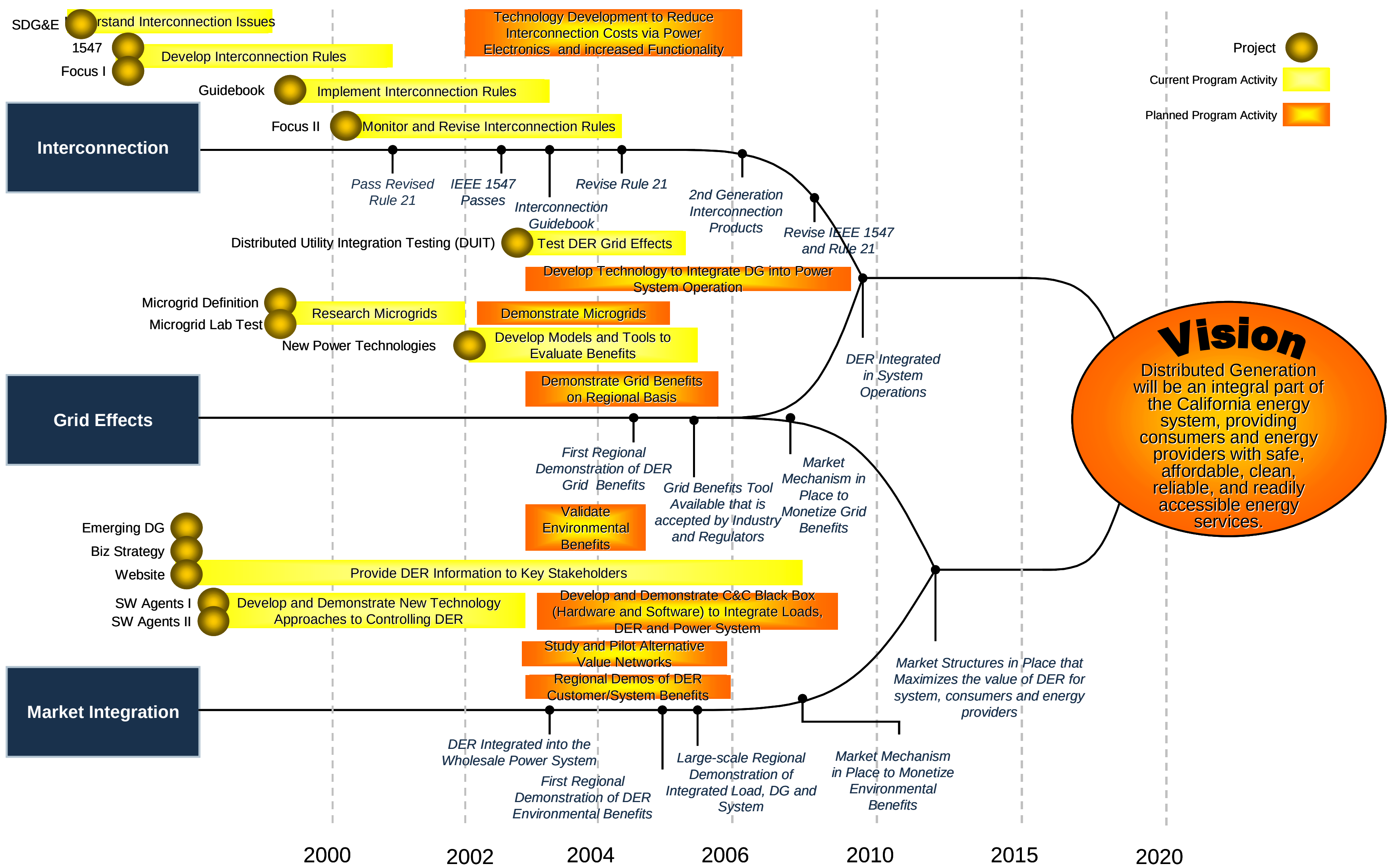

Figure 3: Current Schedule and Projects Applied to Roadmap

External Linkages

The DER Integration Research Program works closely with other PIER programs where there is overlapping interest in DER. Co-funding activities relevant across PIER programs has proven to be an effective way to maximize the benefit and learning given the resource constraints inherent to any research program. External to the CEC, the DER Integration Research Program has developed a close working relationship with the U.S. Department of Energy's (DOE) Distributed Energy and Energy Reliability Program. Co-funding of microgrid research is already taking place through the Consortium for Electric Reliability Technology Solutions (CERTS), a jointly sponsored effort between the DOE and the CEC. Plans for Program co-funding of DOE projects conducted at the National Renewable Energy Lab (NREL) are also being developed.

The Program Advisory Committee (PAC) was established to provide guidance to the DER Integration Research Program to help make the Program a success. The PAC members were selected based on their diverse backgrounds and ability to represent different stakeholder perspectives toward the work undertaken by the Program.

Implementation Activities

In the spring of 2003, the California Energy Commission allocated $7 million for the DER Integration Research Program to pursue research, development and demonstration (RD&D) deemed to be of the highest priority in the 2003-2004 fiscal year (Figure 1). These projects will be conducted in collaboration with the CEC Public Interest Energy Research (PIER) Program's Environmental, Demand Response, and Transmission program areas as well as the U.S. Department of Energy. The DER Integration Research Program will be implementing projects pursuing the following research initiatives: Market Design and Integration Projects ($1.2 million), Regional Grid Benefit Validation Demonstrations ($2.0 million), Interconnection Equipment and Installation Cost Reduction ($0.8 million), and Grid Effects / DG Penetration Testing ($3.0 million).

1.0 Introduction to the DER Integration R&D Plan

The following report provides an overview of the key elements of the R&D planning process of the California Energy Commission's Distributed Energy Resources Integration Research Program (Program). This document seeks to provide the reader with an overall understanding of the process and criteria used in developing the plan, the portfolio management approach used in selecting projects and the organization and resources that support the Program in achieving its objectives. As a living document, the Distributed Energy Resources Integration R&D Plan is intended to aid the Commission's program managers in identifying and seizing upon the most appropriate and timely opportunities to further the advancement of Distributed Energy Resources as a viable energy tool in California given the work already accomplished and insights obtained.

1.1. DER Integration Research Program Background

The Public Interest Energy Research (PIER) was established in 1996 as part of new legislation that includes a requirement that at least $62.5 million be collected annually from investor-owned utility ratepayers for "public interest" energy research and development efforts that are not adequately provided by competitive and regulated markets.

The Energy Systems Integration (ESI) program area within PIER at the California Energy Commission (CEC) is committed to the development of technologies that are cross-cutting and strategically relevant among PIER's various program areas.

Distributed Energy Resources (DER) Integration has been identified as a particularly important part of the ESI program area given its applicability to many areas of research pursued throughout PIER and its potentially revolutionary impact on the energy generation and delivery infrastructure.

1.2. R&D Plan Components

The following sections of this document provide an effective overview of the elements that have shaped the current plans for the DER Integration Research Program. Section 2 introduces the California Energy Commission's Distributed Generation Strategic Plan that sets out the vision for distributed generation in 2020 and the commission-wide mission to contribute toward bringing the vision closer to reality.

The DER Integration Research Program is playing a part in the commission-wide effort with a clearly articulated R&D planning process. The Program's R&D Planning Process can be fundamentally divided into five parts (Figure 4): assess DER research activities, identify priority research initiatives, identify and evaluate projects, construct project portfolio, and execute projects in accordance with the R&D roadmap. An iterative feedback loop embedded in the planning process ensures the Program remains current and relevant, able to respond effectively to changes in the industry's technological and commercial environment.

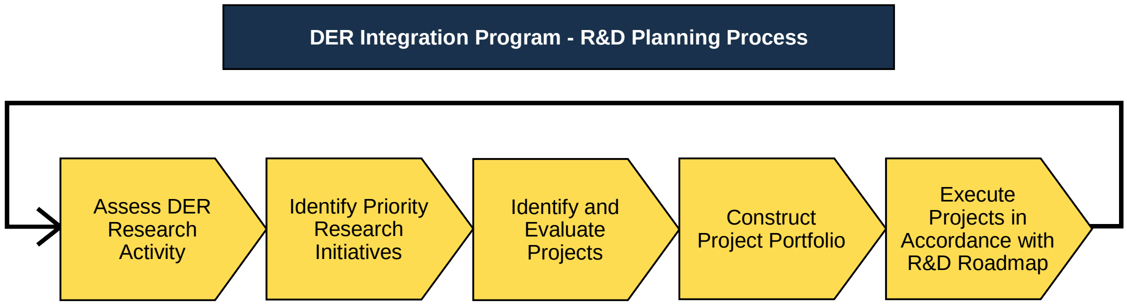

Figure 4: R&D Planning Process

Section 3 presents the research assessment effort that first identified the research initiatives where significant opportunities may exist for DER Integration funding, thereby helping to lay the foundation for the R&D Planning Process. Section 4 describes the value network framework and analysis, which along with the research assessment, help prioritize the research initiatives. Section 5 presents the current and proposed projects of the Program while project evaluation techniques and metrics are presented in Section 6. The portfolio analysis efforts using those techniques and metrics are described in Section 7. Section 8 reveals the DER Integration Research Program's R&D roadmap. Section 9 details the linkages between the DER Integration Research Program and other industry stakeholders. Finally, Section 10 presents the implementation efforts of the Program and closing comments are provided in Section 11.

2.0 California Energy Commission DG Strategic Plan

In June 2002, the California Energy Commission adopted a Distributed Generation (DG) Strategic Plan policy statement with the following mission and vision statement:

Vision: Distributed Generation will be an integral part of the California energy system, providing consumers and energy providers with safe, affordable, clean, reliable, and readily accessible energy services.

Mission: Energy Commission shall lead a statewide effort, which promotes and deploys distributed generation technologies to the extent that such effort benefits energy consumers, the energy system, and the environment in California.

As part of the Strategic Plan, near-term, medium-term, and long-term goals to achieve the vision were laid out (Figure 5).

DG Strategic Plan Goals
Near-term Goals (3-5 years)
• Establish a DG State Agency Coordination Group to cooperatively address DG issues and ensure consistent handling of these issues throughout state government. • Raise consumer awareness about distributed generation by creating and maintaining a central repository of DG general information. • Develop and conduct targeted consumer education campaigns. • Fund research, development and demonstration programs to advance the development and deployment of DG technologies • Assess the market, technological and regional potential for DG to determine a reasonable goal regarding electric generation capacity from DG by 2020. • Identify and address institutional and regulatory barriers, which are interfering with the purchasing, installation, and operation of DG facilities.
Mid-term Goals (5-10 years)
• Reduce DG equipment costs to a level that would obviate the need to provide government incentives to deploy DG. • Enhance the emissions and efficiency profiles of DG technologies, monitoring and modeling techniques, and cost-effective control technologies such that the resulting environmental impacts, public exposure, and permitting support wide-scale deployment. • Establish markets that pay for the full value of DG, including grid benefits, environmental benefits, greenhouse gas reduction credits, energy conservation, and waste reduction benefits. • Certify and deploy DG systems in such a way that procuring DG is as routine, as purchasing appliances for the home.
Long-term Goals (>10 years)
• Make California's energy generation and delivery system the cleanest and most efficient, reliable, and affordable in the nation by maximizing appropriate use of DG. • By 2020, ___ percent of all incremental generation will be DG (see Near-term Goal #5).

Figure 5: Strategic Plan Near, Medium, and Long-Term Goals

Efforts across the California Energy Commission are active in moving toward the vision outlined in the DG Strategic Plan. The varied research activities in PIER complement the commercialization activities in the Renewables Program and Efficiency Division, with Commission policy oversight to make strides toward the vision (Figure 6).

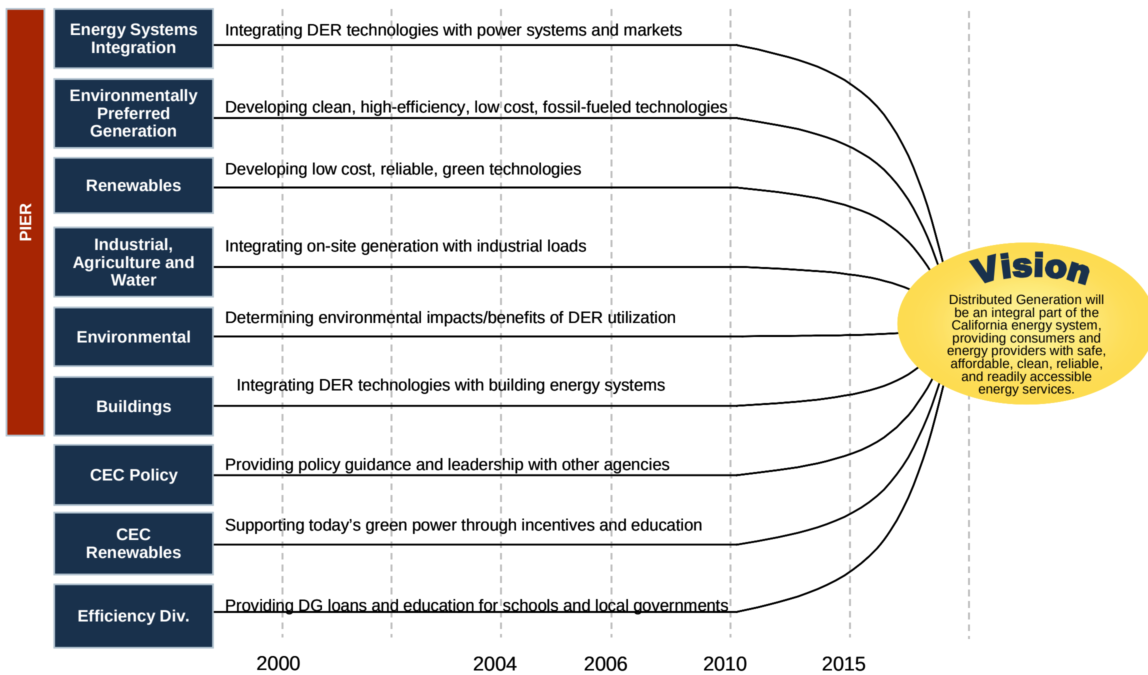

Figure 6. Commission-wide Activities

The DER Integration Research Program is doing its part to support the DG Strategic Plan by translating some of the Strategic Plan's policy goals into actionable research activities (**Error! Reference source not found.**). Collectively, the Program's research activities are addressing these goals, wholly or in part.

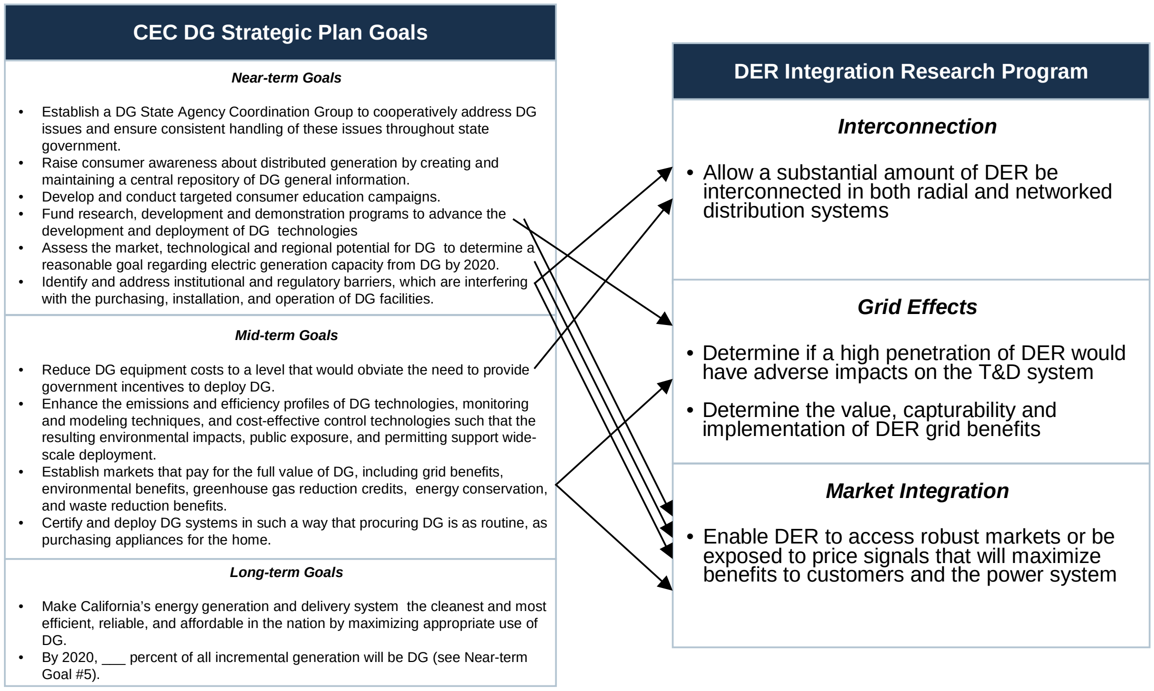

Figure 7. DER Integration R&D Program Support for DG Strategic Plan

3.0 Identification of Research Gaps

3.1. Research Assessment Approach

In the autumn of 2001, Arthur D. Little (now Navigant Consulting) completed an R&D assessment of activities related to Distributed Energy Resources (DER) for the California Energy Commission's Energy Systems Integration program area. Significant developments in DER technology and the marketplace required a fresh analysis of the DER landscape to identify key challenges appropriate for public interest research. The research assessment helped shape the DER Integration Research Program's activities in the following focus areas (Figure 8):

- Interconnection
- Grid Effects
- Market Integration

The research assessment documented a major step in the research plan development process-to understand current research being conducted by industry, nonprofit organizations and government, and to identify where gaps exist.

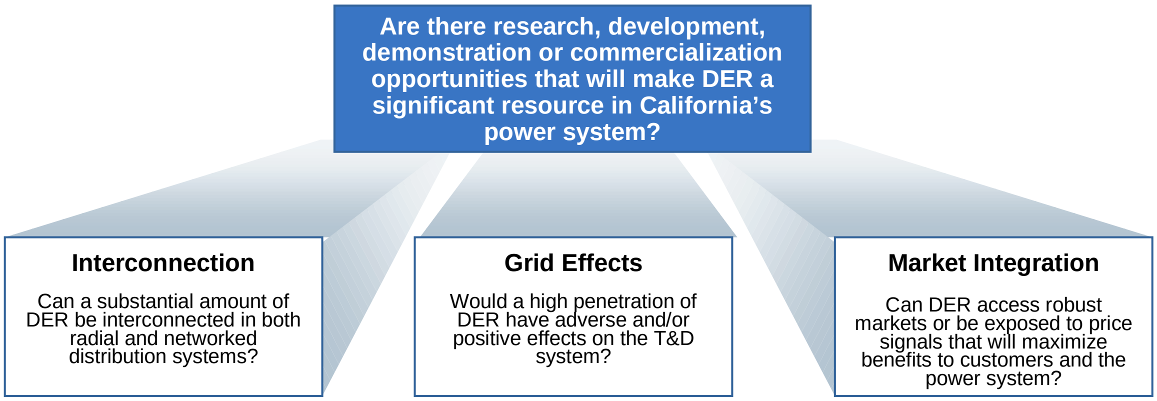

Figure 8. Focus Areas

Information was collected through research, interviews, and a public workshop to identify research gaps and prioritize public funding. A literature search of multiple sources was first conducted to determine past, present and planned research projects in the private and public sectors. Significant additional input was obtained through an interview process with representatives of industry, non-profit and government efforts in DER, and a public workshop held with stakeholders. Key issues and R&D research initiatives to address the three areas of Interconnection, Grid Effects and Market Integration were identified and organized from the acquired information. A framework was created for assessing the status of the DER research efforts (Figure 9). *Issues* are the critical questions facing the development of DER in the areas of interest. These issues have driven, or will drive, the creation of *research initiatives* to address these questions. Current and potential *projects*, in each of the three areas, are pursuing these research initiatives. There are also crosscutting projects that are addressing issues in more than one area. Each project / activity identified can be mapped to the appropriate research initiative and issue.

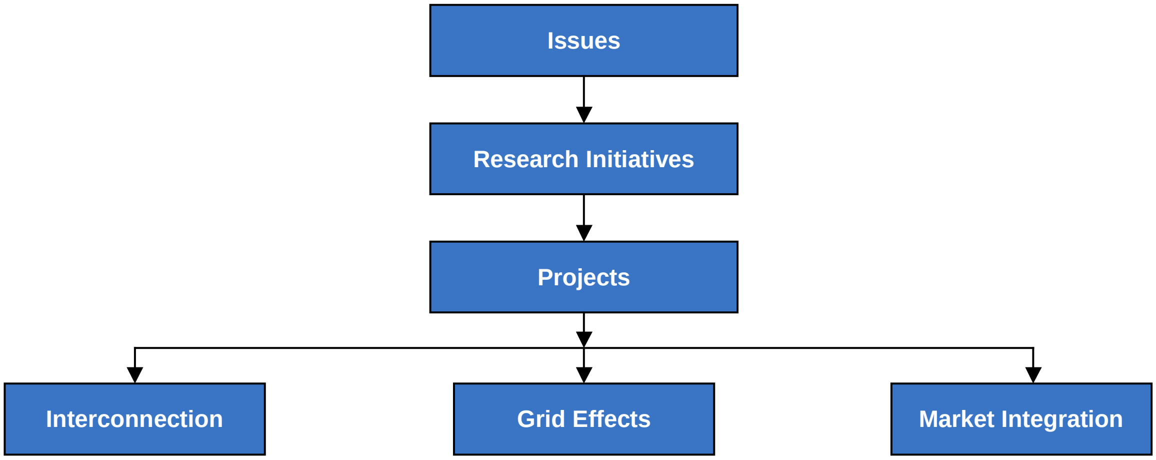

Figure 9. Framework of Analysis

Each of the projects, activities and research initiatives were mapped by its stage of technology development and its competitive impact. The four stages of technology development are research, development, demonstration and commercialization. Competitive impact measures the extent to which a technology is applied and the degree to which a competitive advantage can be attained. Competitive impact follows a pathway through four levels, defined as follows (Figure 10):

Base: Although essential to the business, these technologies do not provide significant competitive advantage

Key: These technologies are critical for today's bases of competition

Pacing: Although they are not fully embodied in current products, they may, if successfully applied, have a substantial impact on the basis of competition in the reasonably near future

Emerging: These technologies may have an impact on competition in the future but this is far from certain

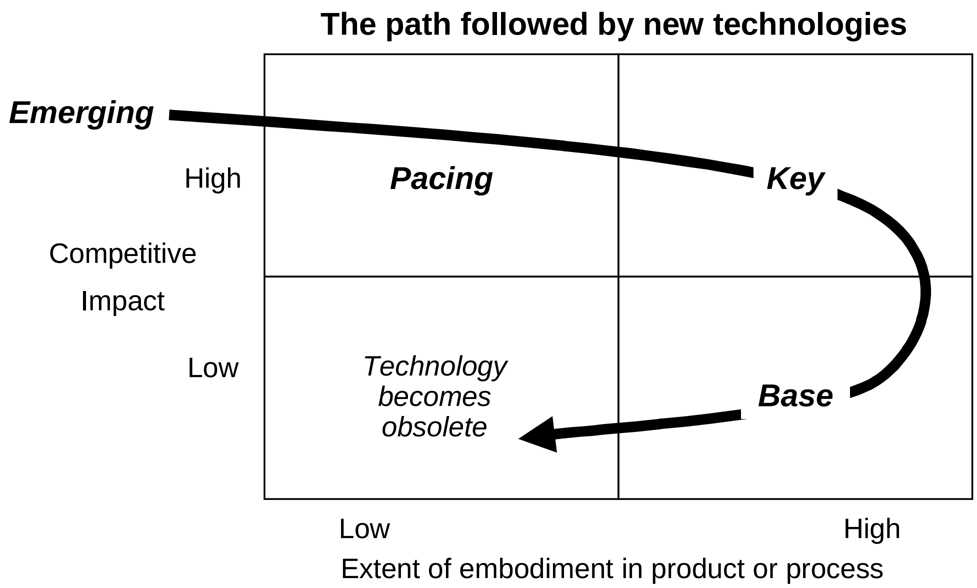

Figure 10. Competitive Pathway

Additionally, the degree to which the research initiatives had been pursued was captured such that each of the research initiatives is identified as either having significant, moderate or little/no gap. A more significant gap implies greater opportunity for public support.

3.2. Interconnection

The research initiatives identified in the Interconnection focus area that would allow for a substantial amount of DER to be interconnected in radial and networked systems, fall into three categories:

- Standardization and adoption of new requirements and processes
- Cost reduction and product improvement
- Compatibility

In all, there are 15 Interconnection research initiatives that match up against four issues (Figure 11).

Interconnection

Can a substantial amount of DER be interconnected in both radial and networked distribution systems?

Issues	Research Initiatives	
	Standardization and Adoption of New Requirements and Processes	**Cost Reduction and Product Improvement**
• Are there safe, reliable and cost-effective interconnection solutions for radial and networked distribution system? • Can interconnection solutions de deployed in a timely fashion? • Can interconnection be made more user-friendly to the end-use consumer?	• Standardize technical requirements, processes and contracts for interconnection (including networked systems and power export) that allow for innovative solutions ➢ Understand impact of and adopt new interconnection requirement • Standardize designs around new requirements ➢ Type testing and certification of interconnection solutions ➢ Develop guidelines and best practices for interconnection • Modify standardized requirements and standardized designs based on modeling, testing and field experience ➢ Educate stakeholders on new requirements, contracts and processes • Develop standardized products for small DER	• Reduce costs of interconnection components • Improve reliability and performance of interconnection components (e.g., power electronics) • Integrate interconnection functions with other DER functions • Turnkey solutions that integrate DER functions • Develop new technologies that would eliminate or reduce some requirements or costs of interconnection
• Is a single DER unit compatible with end-use equipment or other DER equipment?	**Compatibility** • Develop test protocols for compatibility and power quality testing of DER • Test and understand compatibility and power quality issues	

➢ denotes a research initiative found to have a significant gap

Figure 11. Interconnection Issues and Research Initiatives

Interconnection research initiatives with significant gaps are found in the *Standardization and adoption of new requirements and processes* category. There is general consensus that there is a need to support the adoption of new interconnection requirements by industry, customers and utilities. Specifically these research initiatives are:

- Understand impact of and adopt new interconnection requirement
- Type testing and certification of interconnection solutions
- Develop guidelines and best practices for interconnection
- Educate stakeholders on new requirements, contracts and processes.

All of these research initiatives are in the demonstration phase, with the exception of educating stakeholders. With the exception of type testing, they are all base technology research initiatives. Type testing and certification would provide a competitive advantage to individual companies, particularly in the short run as some companies have type tested and/or certified products and others do not. However, there is a collaborative aspect of doing type testing and certification that would be appropriate for public funding. For example, a publicly funded lab or government agency could run the type testing and certification labs and activities. Public funding could also be used to analyze and develop approaches for type testing and certification.

3.3. Grid Effects

In the Grid Effects focus area, there are four categories of research initiatives that could lead to an understanding of what impact a high penetration of DER would have on the electric power system:

- Modeling and testing
- System impact studies
- Microgrids
- Wires company information needs

In all, there are 12 Grid Effects research initiatives that match up against 10 issues (Figure 12).

Grid Effects

Would a high penetration of DER have adverse and/or positive impacts on the T&D system?

Issues	Strategies
•Do we understand what benefits DER can provide to the power system? •Do we understand DER's impact on the grid? •Do we understand how DER will interact with other DER and the grid in real-time? •Is there a limit to the level of DER that the system can absorb without adverse impacts? Can we understand that limit? •Are there limitations on bi-directional power? •Should distribution design philosophy be modified to accommodate DER?	**Modeling and Testing** • Model and analyze the grid with varying levels of DER penetration ➢ Demonstrate and test varying levels of DER penetration in a distribution system • Modify distribution system design approaches
• Can engineering studies be eliminated, standardized or streamlined?	**System Impact Studies** • Develop models to understand system impacts • Develop software to facilitate impact studies • Modify requirements for impact studies as appropriate
• Can microgrids be utilized effectively? • Can the power system or the expansion thereof be built around microgrids?	**Microgrids** • Model and analyze microgrids ➢ Demonstrate and test microgrids • Develop design guidelines for microgrids
• Can we understand the information needs of wires companies with DER deployed in their systems?	**Wires Company Information Needs** • Perform analysis of the information and data needs of wires companies • Develop and demonstrate systems for wires companies to monitor DER

➢ denotes a research initiative found to have a significant gap

Figure 12. Grid Effects Issues and Research Initiatives

The research initiatives with significant gaps in the Grid Effects area are:

- Demonstrate and test varying levels of DER penetration in a distribution system
- Demonstrate and test microgrids

Modeling and analysis of DER's effect on the grid is already underway, but demonstrating and testing DER in a distribution system has barely begun. Unless the benefits and impacts of high degrees of DER penetration are understood through real world demonstration and testing, concerns may not be credibly addressed and modification of distribution system design approaches cannot begin. It was the consensus during the workshop that this area would provide the greatest leverage to the ultimate success of DER. While microgrids have received increased attention of late, much of that work has focused on modeling and analysis. Without demonstrating and testing microgrids, potential stakeholders cannot begin to develop and design guidelines for their operation and understand their value. Both these emerging technology research initiatives are in the demonstration stage and may well require a collaborative element, making them candidates for public funding.

3.4. Market Integration

In the Market Integration focus area, there are three categories of research initiatives that may provide DER with access to robust markets and / or exposure to price signals that will maximize the benefits of DER to customers and the power system:

- Current market
- Advanced market concepts
- Enabling technologies

In all, there are 14 Grid Effects research initiatives that match up against 10 issues (Figure 13).

Market Integration

Can DER access robust markets or be exposed to price signals that will maximize benefits to customers and the power system?

Issues		Strategies	
•Should the DER market paradigm shift toward decentralized rather than centralized control? •Do we understand how DER will impact the assignment of risk? •How should additional DER benefits be captured and monetized (e.g., T&D, reliability, environmental, CHP, etc.)? •Can we aggregate and remotely operate and control DER to better respond to market signals (e.g., energy capacity, ancillary services, and transmission and congestion)? •Can it be made easier for consumers to maximize their investment in DER? •Should standards for communications/control be developed?	•Can market rules/regulations be modified to allow DER to participate in current wholesale markets? Will they be consistent/stable? Can the transaction/ participation costs be reduced for DER? Could the full range of DER participate? •Are there tariffs or rates that could be crafted to provide better retail price transparency to DER? Could the participation costs be reduced? Could the full range of DER participate? •Should a separate market structure (retail market or exchange)be created for the full range of DER technologies? •Could this market be structured to maximize/aggregate the benefits at reasonable costs?	**Current Market** ➢ Assess current wholesale market rules for applicability to DER ➢ Modify market rules as appropriate to reduce the participation costs (fees, metering, process) for DER ➢ Reduce costs by creating critical mass through a demonstration program • Integrate the required technologies to reduce costs of participating in markets ➢ Assess requirements for tariffs or rates ➢ Develop market mechanisms to capture and monetize additional DER benefits (e.g., environmental, CHP,etc.) **Advanced Market Concepts** ➢ Launch a new market for DER that captures all value generated a Start from scratch, develop the best market structure for DER now and in the future b Assess the system requirements for communications, control, metering, software for billing and settlement c Pilot and then launch • Develop advanced control and optimization approaches and technologies (including neural networks and intelligent software agents)	**Enabling Technologies** • Demonstrate aggregation and control of DER • Develop low cost metering • Develop low cost communications and control • Develop software to optimize DER in response to market price signals ➢ Develop standards/protocols for communications/control • Develop advanced storage to optimize DER in response to market price signals

➢ denotes a research initiative found to have a significant gap

Figure 13. Market Integration Issues and Research Initiatives

There are significant gaps in research initiatives in the three Market Integration research initiative categories. The research initiatives with significant gaps in the *Current market* category are:

- Assess current wholesale market rules for applicability to DER
- Modify market rules as appropriate to reduce the participation costs (fees, metering, process) for DER
- Reduce costs by creating critical mass through a demonstration program
- Assess requirements for tariffs or rates
- Develop market mechanisms to capture and monetize additional DER benefits (e.g., T&D, reliability, environmental, CHP, etc.)

Significant work is needed to alter current markets so that they may be able to accommodate DER participation. Following an assessment of the current wholesale market, modification of market rules and possibly tariffs and rates as well as development of market mechanisms to capture the unique benefits provided by various forms of DER can begin to take place. Most of these research initiatives are in the commercial stage of technology development with responsibility for pursuing them falling primarily on regulatory bodies. Therefore, they could not be a prime focus for public technology development funding. However, there might be a research component to understanding how market rules, tariffs and rates ought to be modified. This effort could be done in a collaborative manner supported by public R&D funding. There is also research and analytical work required on DER benefits to better understand their value and how they might be captured. This research initiative is a base / demonstration research initiative making it well suited for public funding. A large-scale demonstration program can help validate concepts and benefits in parallel with the development of new rules and market mechanisms. This demonstration program may also serve to jumpstart the market for DER in California, however it is a pacing research initiative where the ultimate competitive impact is still unknown.

There was one research initiative with a significant gap in the *Advanced Market Concepts* category:

- Launch a new market for DER that captures all value generated – start from scratch, develop the best market structure for DER now and in the future.

Ultimately launching a new market would require regulatory and perhaps legislative action. However, before this market is even piloted, there is a lot of research and analytical work that would need to be done in a collaborative fashion. The ultimate competitive impact of this research is still uncertain and makes it an excellent area for public funding.

There was one research initiative with a significant gap in the *Enabling Technologies* category:

- Develop standards / protocols for communications / control

Creating standards and protocols for communication and control equipment is essential for DER to reach close to its potential in responding effectively to power system and market needs. This research initiative is base, not providing any competitive advantage. It would also require a collaborative effort making it a good opportunity for public funding.

3.5. Research Assessment Observations

From the information obtained, the following observations were drawn:

- Challenges involved with interconnection have just begun to be addressed.
- Research to better understanding the negative impact of DER on the grid needs to be balanced with efforts to better understand the benefits that DER may have on the grid.
- Microgrids are emerging as an important area with DER. However, there is not a common definition of the microgrid concept. In addition, details of how a microgrid is to be effectively operated and controlled to bring about meaningful benefits is still far from clear.
- A lack of a clear successful business model will continue to prevent DER from making a breakthrough into the electricity industry.
- DER integration, optimization and operation are vital to realizing a large penetration of DER. However, understanding the requirements for integration, optimization and operation may not be possible until a clear business model emerges.
- Regulations and policies need to keep pace with and reflect new information and understanding of DER. In many instances, technology is available but deployment is constrained by current policy.
- Significant gaps exist in Interconnection, Grid Effects, and Market Integration research activity where DER Integration Research Program funding can make a dramatic impact.

The priorities for public funding of technology development should be driven by where there are significant gaps in the research initiatives and where it is appropriate for public funding to be invested. The research assessment revealed research initiatives with significant gaps in each of the three areas of analysis: Interconnection, Grid Effects, and Market Integration. These research initiatives all offer a program such as the DER Integration Research Program opportunities to make a significant impact in areas that have not been explored in great detail thus far. The research initiatives most appropriate for public funding of technology development are:

- Those in the base technology area, as these do not provide any one company with a competitive advantage; and emerging and some pacing technologies as it is still too early to tell if they are a source of competitive advantage and more likely to need public funding to remove these uncertainties.
- Research initiatives in the research, development and demonstration phases of the technology development chain; the commercial area should be avoided unless special circumstances exist where private funding is constrained.
- Research initiatives that require collaborative efforts and research initiatives that invoice technology rather than policy development. However, for policy development purposes, there may be a research component to understanding how market rules, tariffs, and rates ought to be modified that would be appropriate for public R&D funding.

4.0 Prioritizing Research Initiatives

4.1. Value Network Framework

From the DER research assessment, a strong need was observed for a viable business model for the Distributed Energy Resources industry. This was deemed critical to developing DER as a viable tool in the electricity infrastructure. The effort began by examining the elements of a successful business model, driven by customer needs, technology and infrastructure, and rules and regulations (Figure 14).

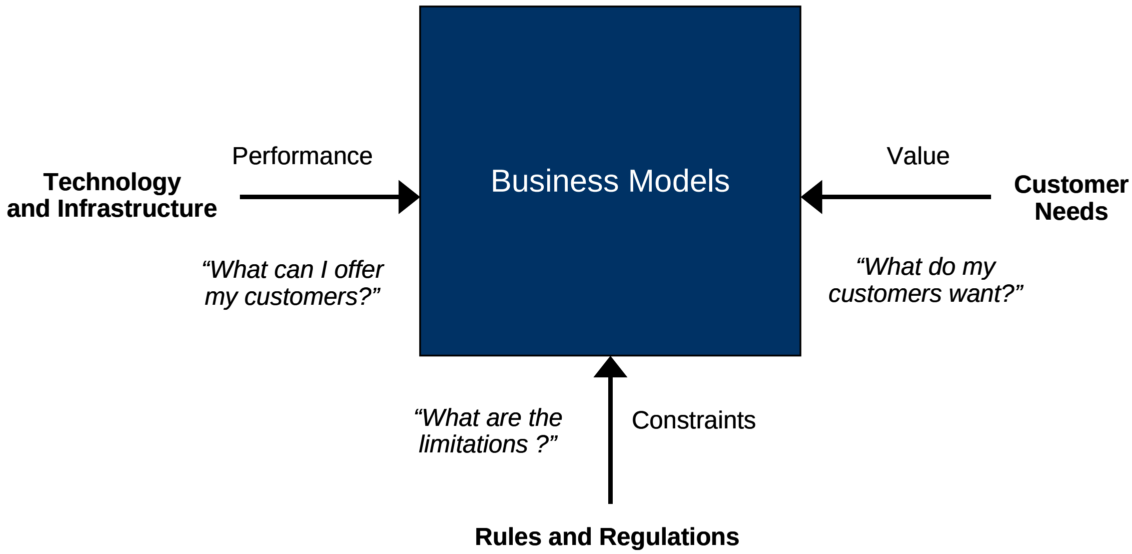

Figure 14. Business Model Overview

Business models work together in a value network that supports a value proposition to the customer (Figure 15).

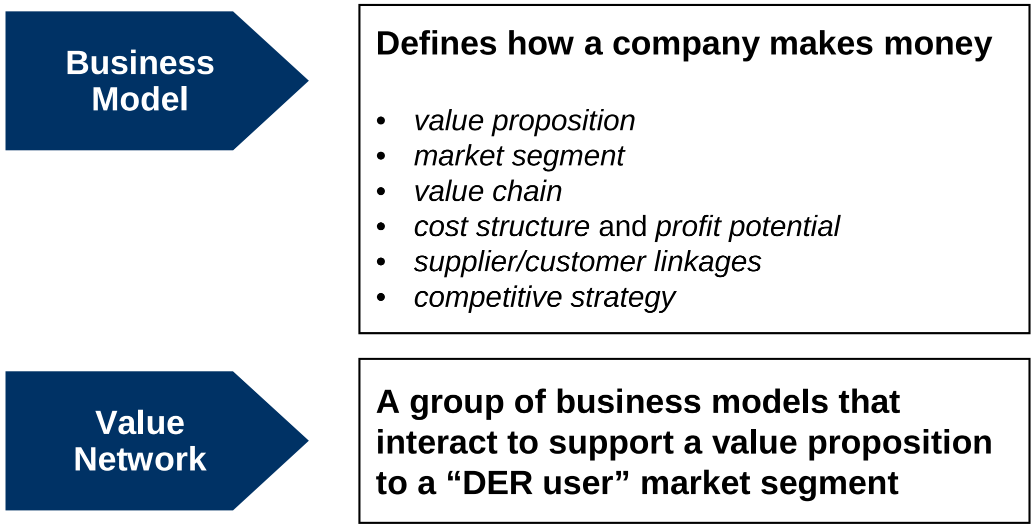

Figure 15. Value Network Concept

After characterizing, identifying, and determining their attractiveness, the results of the value network analysis were combined with that from the research assessment to help the DER Integration Research Program prioritize research initiatives (Figure 16). Before that could take place, a technical market analysis was performed on the value networks to identify those that would have the greatest impact, the value networks' fit with PIER objectives was determined, and the feasibility of bringing the value networks into being was analyzed. The following pages describe the value network analysis steps and interim findings.

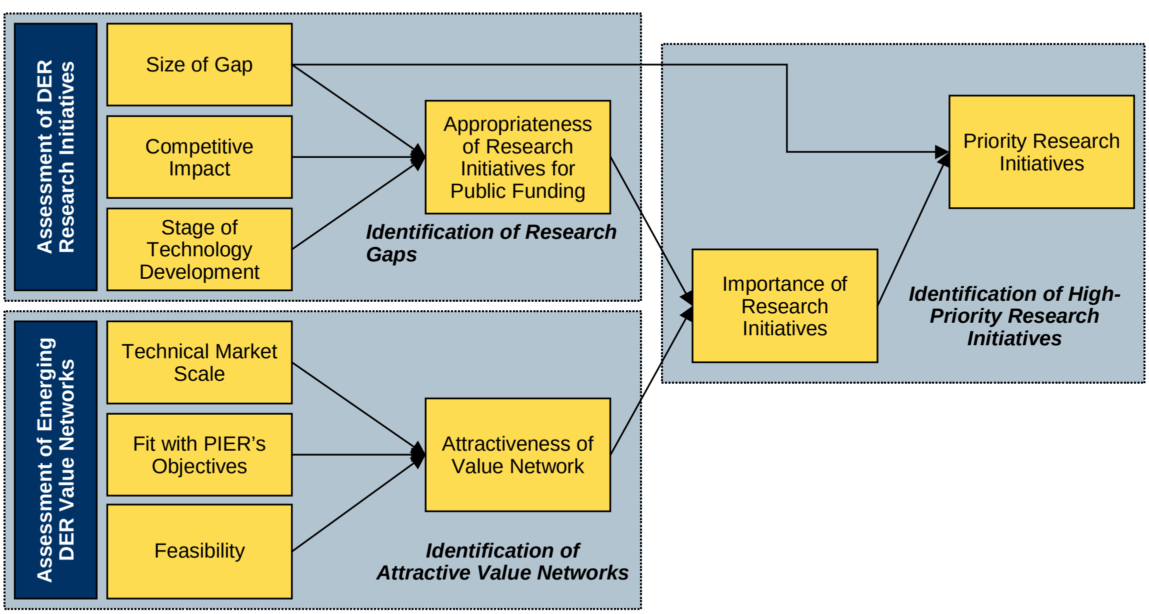

Figure 16. Pathway To Prioritizing Research Initiatives

4.2. Identification of Attractive Value Networks

In order to identify the value networks in Distributed Energy Resources, the market segments of the electricity industry and the values that each market segment seeks were first identified (Figure 17). Each of the four market segments: Energy Supply, Energy Delivery, Energy Consumer, and Society, has a unique value seeking profile.

Taking the Energy Consumer market segment as an example, this market segment is focused on minimizing costs and maximizing electricity reliability for the end user through effective application of DER. An illustration of a business model in action that serves this market segment is the one employed by RealEnergy. As a third-party energy solutions provider, RealEnergy owns and operates onsite combined heat and power (CHP) equipment on behalf of an industrial or commercial energy consumer. In such applications, the additional heat resource generated by the DER equipment is managed for maximum benefit for the energy consumer. Real Energy provides lower electricity and heating/cooling costs for the customer while ensuring high reliability.

Values	Market Segments			
	Energy Supply	Energy Delivery	Energy Consumer	Society
Reliability / Power Quality	—	√	√	—
Energy Cost Savings	—	—	√	—
T&D Benefits	—	√	—	—
Environmental	—	—	—	√
Energy Security	—	—	—	√
Flexibility	—	—	—	—
Capital Management	—	√	—	—
Resource Management	—	—	√	—
Asset Value	—	—	—	—
Capacity	√	√	—	—
Energy Sales	√	—	—	—

Figure 17. Market Segment Value Analysis

Six representative value networks were identified for Distributed Energy Resources in California:

- Energy Cost Saver
- Perfect Power
- Energy Supply & Deliver
- Green Power

- DER Exchange
- Value Convergence

Four value networks have a target market segment and a value proposition, and can exist independent of each other (Figure 18).

Value Network	Market Segment	Value Proposition
Energy Cost Saver	Energy consumer	Provide energy consumers with electricity, thermal energy and reliability at reduced costs and lower risks. The applications will include peak shaving, base load and cogeneration.
Perfect Power	Energy consumer	Provide energy consumers with perfect power via a DG product or service. Perfect power is defined as power that is more reliable (>99.9% availability) and/or of higher quality.
Green Energy	Society, energy supplier, energy consumer	• Society - install clean DER that will displace emissions and save energy • Energy Supply - sell output of DER that will satisfy Renewable Portfolio Standards (RPS) or emissions credits that were created by DER at reasonable cost to energy supply companies • Consumer - sell customers clean energy via DER products or services
Energy Supply & Delivery	Energy supplier and deliverer	Provide energy supply and delivery companies with a lower cost generation, transmission and/or distribution alternative to traditional solutions. Other related benefits include better asset utilization, increased system capacity, improved system performance and a tool for maintenance and financial management

Figure 18. Independent Value Networks

The other two value networks provide a market mechanism or market condition to enable or combine the other value networks (Figure 19).

Value Network	Market Segment	Value Proposition
DER Exchange	Energy supplier and deliverer	• Provide the market mechanism for selling high value, wholesale capacity and energy to energy suppliers and energy delivery companies • Provide the market mechanism for energy supply and delivery companies to engage in transactions for emissions credits, T&D benefits, and green power.
Value Convergence	All market segments	This value network is the intersection of 2 or more value networks. It would allow buyers/sellers to engage in transactions across value networks. This allows different values to be delivered to more than one customer from the same DER unit at times simultaneously. Some examples include: • An energy consumer that installs a CHP system to reduce its energy costs is participating in the Energy Cost Saver value network. This consumer receives payment from the local distribution company for T&D benefits, thus also participating in the Energy Supply and Delivery value network. • A distribution company that installs a PV system on a remote feeder to defer a T&D investment is participating in the Energy Supply and Delivery value network. It also participates in the Green Power value network by selling the green power produced by this PV system to its customers. • A DER developer that installs and owns a CHP system and provides premium power to an internet hotel in Phoenix is participating in the Perfect Power value network. The developer sells the CO_2 credit s to an industrial facility in China, thus participating in the Green Power value network. The developer has oversized the system and sells this excess power to the DER Exchange.

Figure 19. Supplemental Value Networks

As determined in the value network technical market analysis, the Energy Cost Saver and the Energy Supply & Delivery value networks have the largest scale in terawatt hours per year (Figure 20).

Scale Definition	Value Networks Scale					
	Energy Cost Saver	Perfect Power	Green Power	Energy Supply & Delivery	DER Exchange	Value Convergence
Technical Market Potential Analysis	Assume that all loads could be supplied with a DER system Total California load = ~245 TWh/year	Because DER solutions exist in the marketplace, assume that everyone with perfect power needs has a solution Existing standby genset capacity = ~3.2GW Assume that UPS systems that don't use a genset roughly equal those that do. Total = 6.4 GW Because UPS systems are always providing protection, assume capacity factor = 100% = 56 TWh/year	The national cogeneration potential is 133 GW industrial + 77 GW commercial/ institutions = 210 GW California represents about 7.5% of the national load, yielding 16 GW potential for California. Assuming a 70% capacity factor, provides 98 TWh/year PV technical potential covering all rooftops that have PV access ~ 4,000 million sq. ft. = 40 GW @ 20% CF = 70 TWh Total Cogen + PV = 168 TWh	Assume that all loads could be supplied with a DER system Total California load = ~245 TWh	Assume that all loads are supplied by DER (245 TWh evenly split among three value networks: ECS, green power and ESD. Assume 10% of the ECS, 30% of the green power and 100% of the ESD is sold through the exchange. Green = (245/3*30%) = 24 TWh ECS = (245/3*10%) = 8 TWh ESD = (245/3*100%) = 82 TWh Total = 114 TWh	It is difficult to estimate the technical market for this value network. A high rating would require the majority of the Energy Cost Saver and Energy Supply and Delivery value networks to converge *or* all of the Green Power or DER Exchange to converge with another value network.
Relative Technical Market Scale	High	Low	Medium	High	Medium	Medium

Figure 20. Value Networks PIER Objectives Fit Analysis

The Energy Cost Saver and DER Exchange have the greatest fit with PIER objectives (Figure 21).

PIER Objectives	Value Networks Fit Assessment					
	Energy Cost Saver	Perfect Power	Green Power	Energy Supply & Delivery	DER Exchange	Value Convergence
Low Cost Power	++	+	-	+	++	+
Reliable Power	+	++	~	+	+	+
Reduce Environmental Impact	+	~	++	+	+	+
Increased Safety	~	~	~	~	~	~
Relative Fit	High	Medium	Low	Medium	High	Medium

Very Positive: **++** **Positive:** **+** Neutral: **~**
Negative: **-** Very Negative: **--**

Figure 21. Value Networks PIER Objectives Fit Analysis

The Perfect Power value network has the highest feasibility rating among the value networks (Figure 22). Feasibility is defined as the probability of development of the value network assuming the public sector closes the research gaps appropriate for public funding (i.e. how much R&D will be required by the private sector in addition to public sector R&D.)

Number of Initiatives NOT appropriate for Public Research that are Necessary for that Value Network						
	Energy Cost Saver	Perfect Power	Green Power	Energy Supply & Delivery	DER Exchange	Value Convergence
Significant Gaps	3	0	2	3	6	+3***
Moderate Gaps	7	4	3	3	5	+1***
Relative Feasibility	Medium Low	High	Medium High	Medium	Low	Low

* Feasibility defined as the probability of development of the value network assuming the public sector closes the research gaps appropriate for public funding (i.e., how much R&D will be required by the private sector in addition to public sector R&D)

** In calculating relative feasibility, significant gaps had double the weight of moderate gaps

*** Gaps under value convergence considered in addition to gaps in at least two other value networks

**** Assessment of Necessity, gap, competitive impact and stage of technology development for every research initiative included in Appendix

Figure 22. Value Networks Feasibility Analysis

By combining the results of the technical market size, fit with PIER objectives, and feasibility analysis, the Energy Cost Saver and Energy Supply and Delivery value networks are rated most attractive for DER Integration Research Program (Figure 23). Relative attractiveness was calculated by averaging the scores for scale, fit and feasibility (all with the same weight), and normalizing the result.

Criteria	Value Networks Attractiveness					
	Energy Cost Saver	Perfect Power	Green Power	Energy Supply & Delivery	DER Exchange	Value Convergence
Relative Technical Market Scale	High	Low	Medium	High	Medium	Medium
Relative Fit	High	Medium	Low	Medium	High	Medium
Relative Feasibility	Medium Low	High	Medium High	Medium	Low	Low
Relative Attractiveness*	**High**	**Medium**	**Medium Low**	**High**	**Medium**	**Low**

* Relative attractiveness was calculated by averaging the scores for scale, fit and feasibility (all with the same weight) and normalizing the result.

Figure 23. Most Attractive Value Networks

4.3. Research Initiative Prioritization

ESI's DER research priorities were identified based on DER research gaps and emerging DER value networks. The necessity of research initiatives from each focus area to each value network was evaluated. The importance of each research initiative was calculated by combining the necessity of the research initiative with the attractiveness for each value network. Research priority ratings were based on importance of each research initiative and the size of the research gap. Research initiative importance was calculated for each focus area.

No new research initiative in the Interconnection focus area has a high or medium high importance rating (Figure 24).

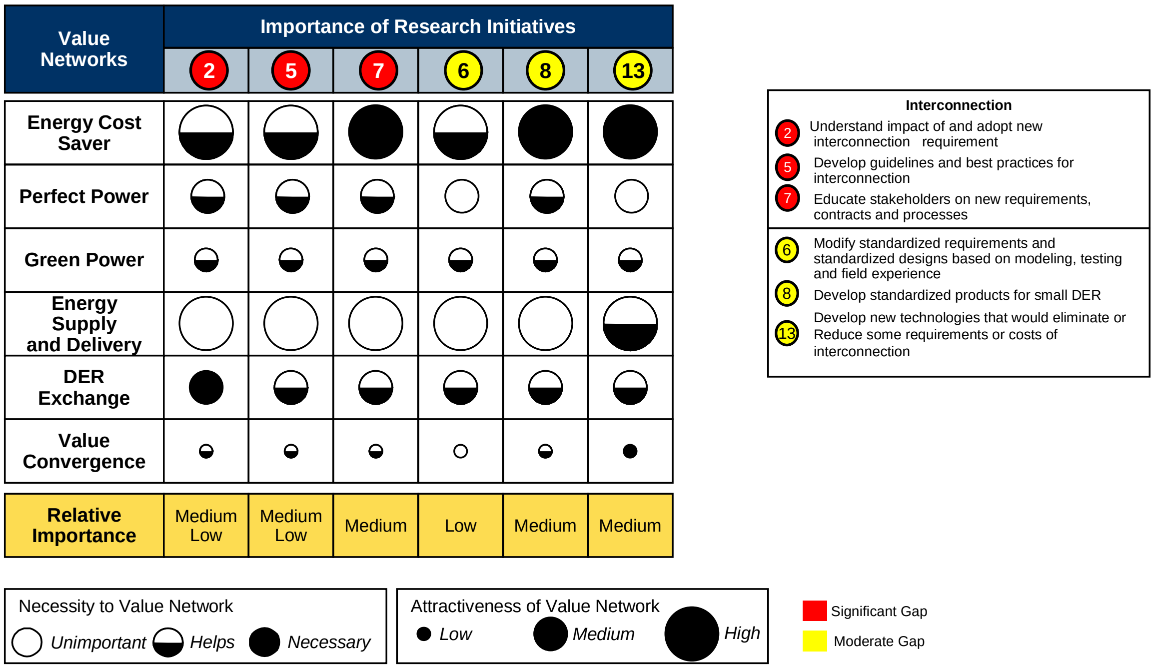

Figure 24. Interconnection Research Initiative Priority Ratings

Two research initiatives in Grid Effects have high importance and four have medium high importance ratings (Figure 25). "Perform analysis of the information and data needs of wires companies" and "develop and demonstrate systems for wires companies to monitor DER" have high importance ratings. "Demonstrate and test varying levels of DER penetration in a distribution systems", "Model and analyze the grid with varying levels of DER penetration", "Develop models to understand system impacts", and "Develop software to facilitate impact studies" received medium high importance ratings.

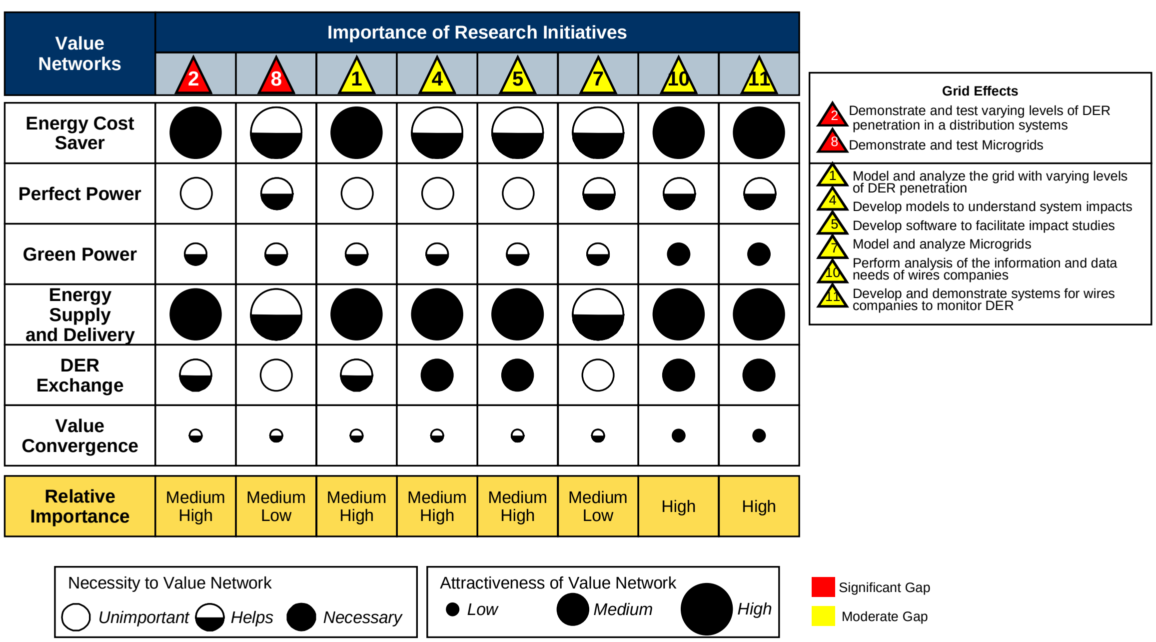

Figure 25. Grid Effects Research Initiative Priority Ratings

Two research initiatives in Market Integration have high importance and two have medium high importance ratings (Figure 26). "Develop market mechanisms to capture and monetize additional DER benefits (e.g., T&D, reliability, environmental, CHP, etc.)" and "Develop software to optimize DER in response to market price signals" have high importance ratings. "Demonstrate viability of a value network through a replicable pilot program" and "Develop advanced control and optimization approaches and technologies" have medium high ratings.

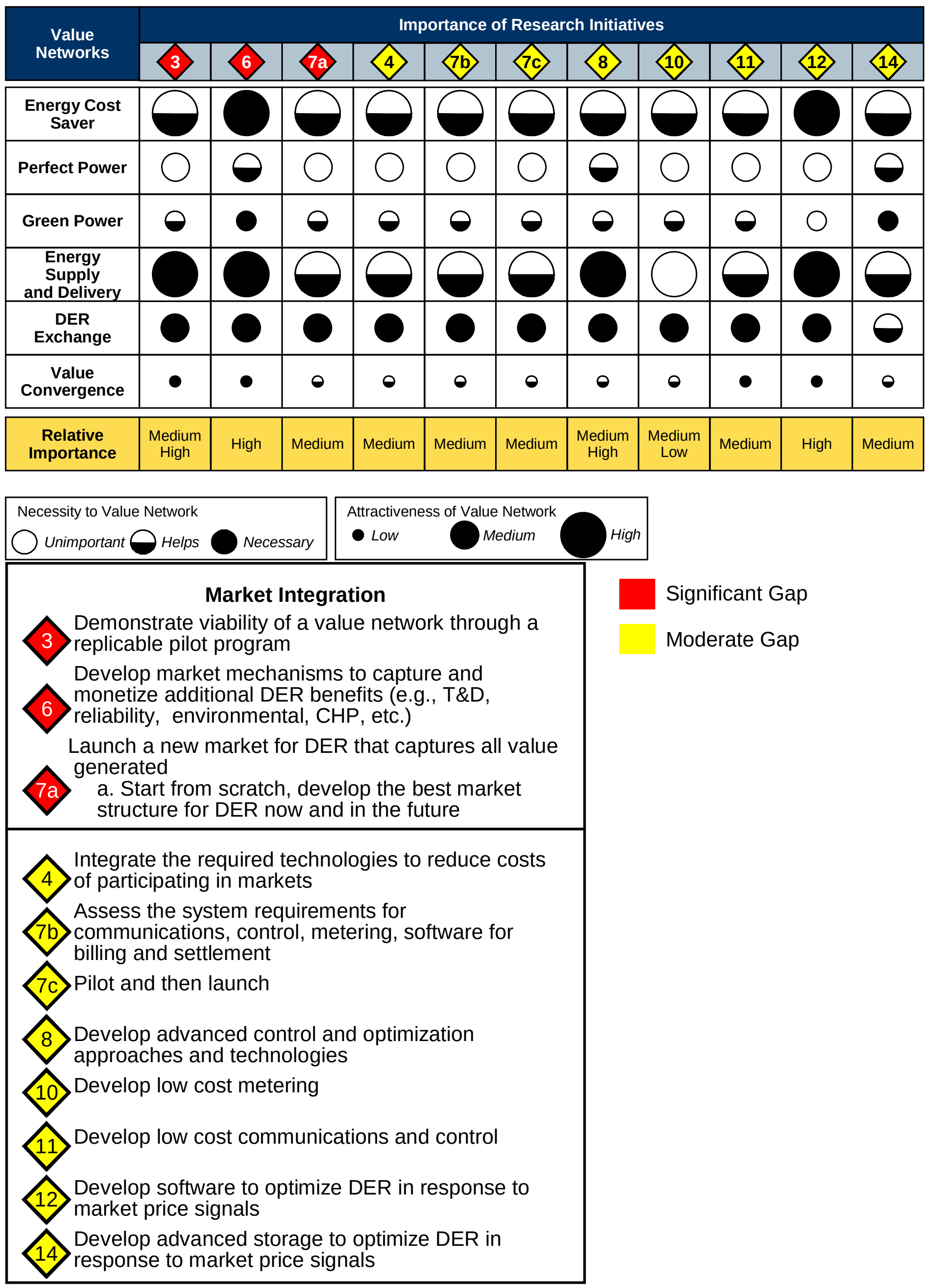

Figure 26. Market Integration Initiative Priority Ratings

An additional focus area was formed to specifically isolate DER Technologies and Products. In this focus area, one research initiative among the recent additions has a high importance and one more has a medium high importance rating (Figure 27). “Reduce emissions from DER technologies” has a high importance rating and “Reduce equipment and installation costs of DER technologies” has a medium high rating.

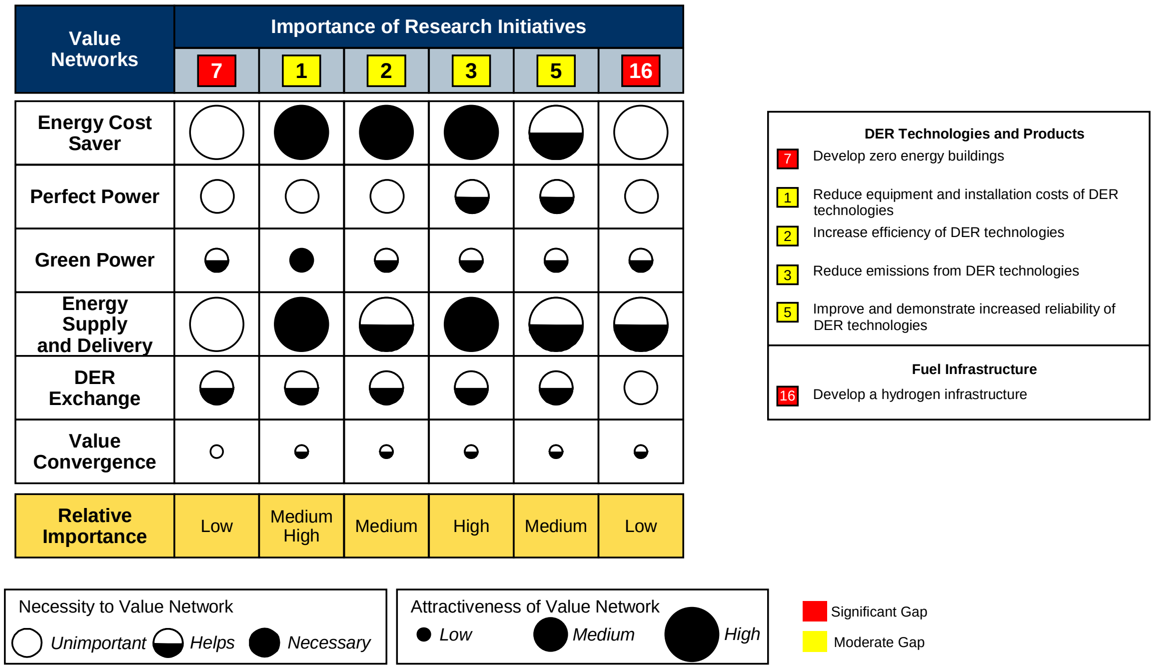

Figure 27. DER Technologies and Products Research Initiative Priority Ratings

In all, fourteen research initiatives from across the different focus areas were identified as high priority, based on their relative research gap size and importance (Figure 28).

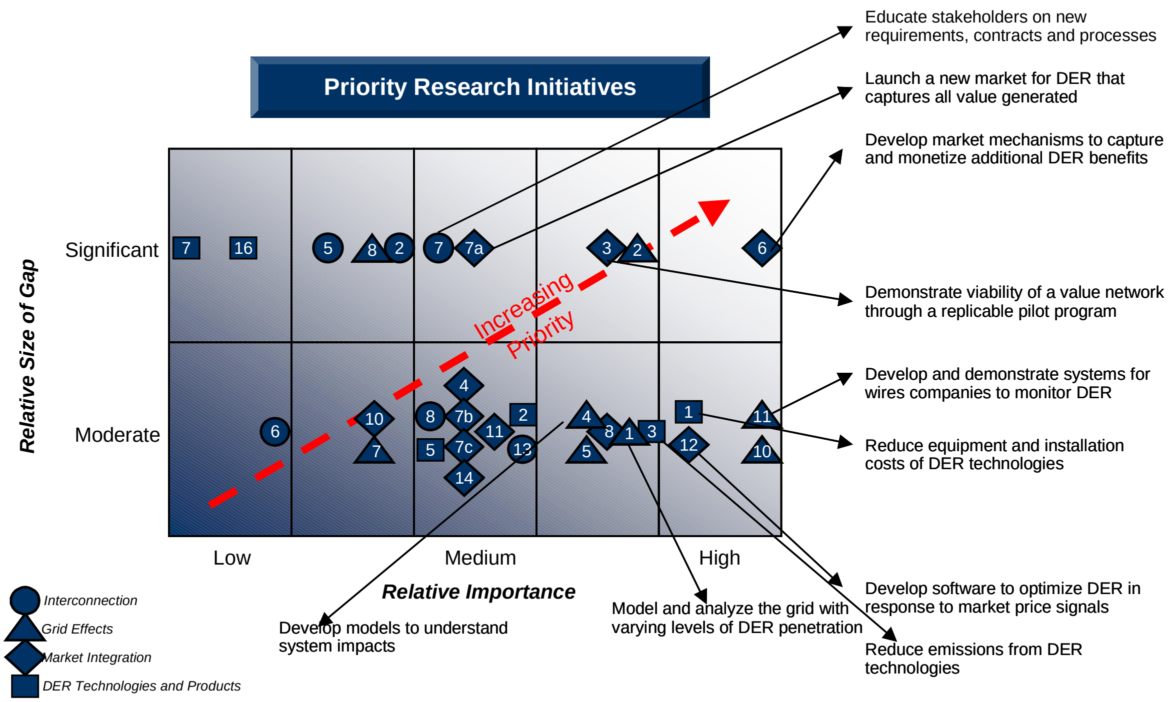

Figure 28. High Priority Research Initiatives

5.0 Current and Proposed Projects

5.1. Current Projects

Promising research is already in the pipeline. DER Integration Research Program activities currently include a portfolio of 10 projects with a total estimated budget requirement of over $6 million for the lifetime of these projects (Figure 29).

Projects	Investment	Focus Area	Results Expected
AESC Advanced Communication & Control Technology Field Demonstration	$550k	Market Integration	2nd Qtr 2004
CERTS Microgrid Development and Laboratory Testing	$1.5 million	Interconnection Grid Effects Market Integration	4th Qtr 2004
CERTS Standard Power Electronic Interfaces Design Concepts	$75k	Interconnection Grid Effects	4th Qtr 2004
Interconnection Rule Development and Refinement	$497k	Interconnection	Ongoing
Interconnection Monitoring Program	$745k	Interconnection	Available now
Interconnection Guidebook	$62k	Interconnection	3rd Qtr 2003
IEEE 1547/Rule 21 Coordination	$74k	Interconnection	Ongoing
DUIT Laboratory testing of varying DER levels in distribution systems	$2 million	Interconnection Grid Effects	4th Qtr 2003
New Power Technologies regional integrated T&D modeling tools for assessing locational benefits of DER	$616k	Grid Effects Market Integration	4th Qtr 2003
E2I Partnership to address market integration issues (e.g., rates and tariffs)	$250k	Market Integration	2nd Qtr 2004

Figure 29. Current Active Projects

5.2. Proposed Projects

Potential projects for the DER Integration Research Program were scoped to address the high priority initiatives identified in the value network analysis. In addition to addressing the research initiatives, the proposed projects also have linkages to many other California Energy Commission activities (Figure 30). The 35 proposed projects were reviewed and characterized to simplify the project selection process. These 35 projects were consolidated into 23 projects that were scoped in greater detail). For each project, objectives, desired results, needed investment, and timeframe were scoped. Opportunities for leveraging time (i.e., in-kind time commitment), talent (i.e., capability and expertise to perform research) and treasure (i.e., financial resources) were identified. Opportunities to partner with other Commission programs were also considered. Finally, risks and methods for project implementation were characterized.

Priority Research Initiatives	Project Ideas - Linkages to other CEC Programs
A. Develop market mechanisms to capture and monetize additional DER benefits	J1. Integrate AESC technology into field demonstration A2. Paper study to quantify value of DER and develop common metrics – Linkage with Renewables, Buildings programs A3. a) Develop (if necessary) and implement tools to determine the value of DER to a particular regional problem –Link Regional A3. b) Understand technical options and develop price signals (e.g., tariffs, incentives, etc.) to elicit a regional response–Link Regional A3. c) Demonstrate and evaluate regional solutions A4. Understand effect of DG on environmental (addressing central system complexity) – Linkage with Environmental program A5. Develop business case for utility DER – Linkage with DR program A6. Economic analysis on utility DER ownership / market power – Linkage with CSEM UC Berkeley program A7. Aggregated Distributed Generation Pilot Program – Linkage with CAISO, DR programs
B. Perform analysis of the information and data needs of wires companies	B1. Develop Command, Control and Communications Integration plan (C^3I Plan) – Linkage with DR, Transmission programs B2. System operator DER information needs assessment – Linkage with DR, Transmission, Renewables, EPAG B3. Options analysis for DER system operator information needs – Linkage with DR, Transmission, Renewables, EPAG
C. Develop and demonstrate systems for wires companies to monitor DER	B1. Develop Command, Control and Communications Integration plan (C^3I Plan) – Linkage with DR, Transmission programs C1. Demonstrate adaptive feeder protection and coordination – Linkage with DR, Transmission programs C2. Demonstrate different information monitoring systems for system operators – Linkage with DR, Transmission, Renewables, EPAG
D. Reduce equipment and installation costs of DER technologies (major reductions)	B1. Develop Command, Control and Communications Integration plan (C^3I Plan) – Linkage with DR, Transmission programs D1. Determine what the interconnection cost for DER should be – Linkage with EPAG program D2. Analyze total life cycle efficiency (including fuel) of different technologies – Linkage with EPAG, Renewables programs D3. Power electronics E.G. inverters (improved reliability) – Linkage with Renewables program D4. Low cost PV (e.g., organic) - Linkage with Renewables program D5. Standardize Inverter Design
E. Develop software to optimize DER in response to market price signals	A7. Aggregated Distributed Generation Pilot Program – Linkage with CAISO, DR programs E1. Combined DR-DER price signal software - Linkage with DR program
F. Demonstrate and test varying levels of DER penetration in a distribution systems	F1. Clemson demo of DER (potential follow on to ESI DUIT project)
G. Demonstrate viability of a value network through a replicable pilot program	J1. Integrate AESC technology into field demonstration A5. Develop business case for utility DER – Linkage with DR program B1. Develop Command, Control and Communications Integration plan (C^3I Plan) – Linkage with DR, Transmission programs B2. Pilot demonstration of DER T&D benefits with utility – Linkage with DR, Transmission programs A3. c) Demonstrate and evaluate regional solutions (replaced G1 and G4) G2. Test DG as enabler for DR (and vice versa) – Linkage with DR program G3. a) Solicit field demonstration of DER value network Green Power G3. b) Solicit field demonstration of DER value network Energy Supply and Delivery G3. c) Solicit field demonstration of DER value network DER Exchange
H. Reduce emissions from DER technologies	A4. Understand effect of DG on environment (addressing central system complexity) – Linkage with Environmental program H1. Effect of CARB rules on technology choice and development – Linkage with EPAG, Environmental programs H2. Environmental/Economic dispatch strategies – Linkage with EPAG, Environmental programs H3. Develop common metric for DER emissions comparative regarding displaced technology/capacity that is technology neutral H4. Alternative fuels study (hydrogen infrastructure) – Linkage with Transmission, EPAG, Renewables programs
I. Model and analyze the grid with varying levels of DER penetration	B1. Develop Command, Control and Communications Integration plan (C^3I Plan) – Linkage with DR, Transmission programs I1. Analyze existing distribution equipment for two way flow
J. Develop advanced control and optimization approaches and technologies (e.g., neural networks and intelligent software agents)	J1. Integrate AESC technology into field demonstration – Linkage with DR program A5. Develop business case for utility DER – Linkage with DR program B1. Develop Command, Control and Communications Integration plan (C^3I Plan) – Linkage with DR, Transmission programs B2. Pilot demonstration of DER T&D benefits with utility – Linkage with DR, Transmission programs
K. Develop models to understand system impacts	K1. Develop model from DC analysis (that can be used in field)
L. Develop software to facilitate impact studies	L1. Develop a DC analysis for distribution (within 15% accuracy)
M. Develop the best market structure for DER that captures all value generated	A5. Develop business case for utility DER – Linkage with DR program B1. Develop Command, Control and Communications Integration plan (C^3I Plan) – Linkage with DR, Transmission programs M1. Create 2020 vision for market structure (end point) – Linkage with Policy, DR programs M2. Paper study of technology road maps and benefits of alternative visions – Linkage with DR program M3. Hydrogen economy – Linkage with DR program
N. Educate stakeholders on new interconnection requirements, contracts and processes	

Figure 30. Proposed Project for Priority Research Initiatives

J1. (Formerly A1) Integrate AESC into field demonstration

– Project Objective: Can we control a diverse array of sources and loads in real time? Can we improve the economic efficiency? Will it be fast enough, cheap enough, reliable enough to participate in energy market?
– Desired Results: To demonstrate feasibility of AESC technology for economically controlling multiple DER devices to respond to simulated market signals.
– Project Investment: Medium $500k to $3MM (estimated to be $1.5 MM)
– Timeframe: 18 months
– Leverage:
  – Time: California State University for demo sites. Need large customers.
  - Talent: AESC, manufacturer for software, hardware.
  - Treasure: DWR
– Additional resources: None
– Implementation Risk: Low
– Technology/Market Risk: High
– Solicitation Type: Sole source (Follow on AESC contract)

A2. Paper study to quantify value of DER and develop common metrics

– Project Objective: Develop a methodology that accurately and consistently quantifies DER value and confidence level of those values being realized. This preliminary work would be useful for creating a market structure (e.g., model tariffs, etc). This is accomplished by creating common metrics for reliability, T&D benefits, emissions, ancillary services, … then converting the metrics to $.
– Desired Results: Prioritization of DER benefits based on absolute values and complexity of calculation. Three main deliverables are: 1)What is the value of the benefit, 2)How is the benefit calculated, and 3)How difficult is the calculation.
– Project Investment: Paper study = Low <$500k (Implementation - may not be part of R&D project = High > $3MM)
– Timeframe: Paper study = ~1yr. (Implementation = 1-3yr)
– Leverage:
  – Time: Partner with regulatory groups, PIER Renewables, vendors, UDCs, NREL
  – Talent: Sherman Auerbach, E3, DUA
  – Treasure: DOE
– Additional resources: None
– Implementation Risk: Low
– Technology/Market Risk: Medium
– Solicitation Type: EISG Grant, Competitive Solicitation (~ 3 awards)

A3. a) Develop (if necessary) and implement tools to determine the value of DER to a particular regional problem

– Project Objective: The primary objective is to understand the real world value of DER in addressing regional problems. These problems may include grid constraints, reliability, environmental. A secondary objective may be to develop tools that will allow for easy and credible analysis of benefits.
– Desired Results: Analysis of the benefits and costs of deploying DER as a solution to regional problems. This analysis must of the credibility with all stakeholders so that the results can be replicated in other regions. It is likely that there would be several projects addressing different problems in different regions.
– Project Investment: Medium $500k to $3MM (estimated to be $1 MM)
– Timeframe: 9 months
– Leverage:
  – Time: Coops, Munis, consumer groups, trade associations, local governments
  – Talent: Software companies
  – Treasure: Local governments, Munis, E2I
– Additional resources: DR program, PIER Renewables, Environmental
– Implementation Risk: Low
– Technology/Market Risk: Medium
– Solicitation Type: Broad solicitation that encourages creative partnerships and approaches. Opportunistic projects will be considered. The ESI team may also be a catalyst for a particular regional problem or group of stakeholders.

A3. b) Understand technical options and develop price signals (e.g., tariffs, incentives, etc.) to elicit a regional response

– Project Objective: Understand the technical options to providing price signals that will unlock the value identified in Project A3.a. The analysis of these options will provide a preferred approach.
– Desired Results: An analysis of different options to provide price signals to enable a DER solution to regional problems. Options that can be easily replicated will be preferred.
– Project Investment: Medium $500k to $3MM (estimated to be $1 MM)
– Timeframe: 9 months
– Leverage:
  – Time: Coops, Munis, consumer groups, trade associations, local governments
  – Talent: Software companies
  – Treasure: Local governments, Munis, E2I
– Additional resources: DR program, PIER Renewables, Environmental
– Implementation Risk: Low
– Technology/Market Risk: Medium/High
– Solicitation Type: Some projects will be follow on to A3.a. A broad solicitation will generate other projects where the DER value is well understood. The solicitation will encourage creative partnerships and approaches. Opportunistic projects will be considered. The ESI team may also be a catalyst for a particular regional problem or group of stakeholders.

A3. c) Demonstrate and evaluate regional solutions

- Project Objective: Demonstrate DER as a solution to regional problems that will prove the value of various DER benefits.
- Desired Results: Evaluation of DER regional solution demonstrations to document the value and validity of DER benefits and approaches to unlock this value.
- Project Investment: Medium $500k to $3MM (estimated to be $1 MM)
- Timeframe: 24 months
- Leverage:
  - Time: Coops, Munis, consumer groups, trade associations, local governments
  - Talent: Software companies
  - Treasure: Local governments, Munis, E2I
- Additional resources: DR program, PIER Renewables, Environmental
- Implementation Risk: Medium/High
- Technology/Market Risk: Medium/High
- Solicitation Type: Some projects will be follow on to A3.a and b. A broad solicitation will generate other projects where the DER value is well understood. The solicitation will encourage creative partnerships and approaches. Opportunistic projects will be considered. The ESI team may also be a catalyst for a particular regional problem or group of stakeholders.

A4. Understand effect of DG on environment (addressing central system complexity) – Linkage with Environmental, Renewables programs

- Project Objective: Analyze the environmental impact of DER on a systems level (i.e., impacts including air, land and water). Analysis should include effects in reduction in system loses, locational impacts, different technologies, life cycle implications, fuel infrastructure and quantify monetary value of emission reduction.
- Desired Results: Model and report with understanding of system wide environmental impacts under different DER deployment scenarios
- Project Investment: Medium (+$1MM)
- Timeframe: 18 months
- Leverage:
  - Time: CARB, NRDC, PIER Environmental, PIER Renewables
  - Talent: UC, ICF, TIAX-Accurex, (ask Kelly Birkenshaw)
  - Treasure: EPA, DOE
- Additional resources: None
- Implementation Risk: Medium
- Technology/Market Risk: Medium
- Solicitation Type: Broad solicitation

A5. Develop biz case for UDC DER

- Project Objective: Find a win-win-win approach for UDCs, rate payers, and the state to help the UDCs participate in DER market. UDCs must be able to make a profit commensurate with what they make from T&D construction. Ratepayers must get more reliable service at an equal to or lower cost. The state gets stronger economy (stable lower cost energy), cleaner environment, and more efficient system. UDC becomes the champion for DER to CPUC such that DER market grows and unit costs decrease. Currently, UDCs have no incentive to explore/support a DER market place. They are currently a barrier, that's the gap.
- Desired Results: Utility and ratepayer economic analysis of UDC deployment of DER and recommendations for regulatory changes to accommodate this business case. Project Investment: Low <$500k (if done with E2I, would not impact ESI budget)
- Timeframe: < 1yr
- Leverage:
  - Time: Partners include UDCs, vendors
  - Talent: VCs, Consultants, EPRI
  - Treasure: VCs, vendors, UDCs, E2I, etc..
- Additional resources: None
- Implementation Risk: Medium
- Technology/Market Risk: High
- Solicitation Type: Tech support or membership

A6. Economic analysis on utility DER ownership / market power – Linkage with CSEM UC Berkeley program

- Project Objective: Understand market power issues associated with utility ownership of DER
- Desired Results: Analysis of whether utilities could create market power via DER ownership/business practices and regulatory recommendations that balance benefits of DER with market power issues.
- Project Investment: Small
- Timeframe: <1yr
- Leverage:
  - Time: CPUC
  - Talent: CSEM
  - Treasure:Unknown
- Additional resources: None
- Implementation Risk: Low
- Technology/Market Risk: Low/Medium
- Solicitation Type: Sole source amendment (UC Berkeley CSEM)

A7. Aggregated Distributed Generation Pilot Program – Linkage with CAISO, DR programs

– Project Objective: Evaluate, develop and demonstrate the best program for DER to be aggregated for participation in wholesale electricity markets. This requires identifying the appropriate market signals and optimal IT, communications and control technologies.
– Desired Results: Demonstration of aggregated DER participation in wholesale electricity markets including assessment of IT, communications and control technologies.
– Project Investment: Medium ($500k - $3MM)
– Timeframe: 18 months
– Leverage:
  – Time: CAISO, CPA
  – Talent: DER C&C vendors, aggregators, scheduling coordinators
  – Treasure: CPA
– Additional resources: None
– Implementation Risk: High
– Technology/Market Risk: Medium
– Solicitation Type: Sole source and/or grant

B1. Develop Command, Control and Communications Integration plan (C3I Plan) – Linkage with DR, Transmission programs

– Project Objective: DER, DR and the distribution system can and should leverage the same C3I infrastructure. There is likely to be a need to make an investment in this infrastructure over the next decade. The objective of this project would be to bring the stakeholders of these technologies together to understand the needs of these different technologies in regards to C3I and to develop a technology development plan.
– Desired Results: A technology development plan that addresses the needs of DER, DR and the distribution, accounts for uncertainty and provides credible, consensus-driven guidance for technology development.
– Project Investment: Low ($250,000 - $400,000)
– Timeframe: 1 year to 18 months
– Leverage:
  – Time: DOE-Transmission, DOE-DER, OEM's (Alstom ESCA, Siemens, Engage Networks, Sixth Dimension), California UDCs, CPA, ISO
  – Talent: Same as Time and EPRI-CEIDS, CERTS
  – Treasure: DOE-Transmission, DOE-DER, E2I, EPRI-CEIDS
– Additional resources: DR, Transmission Programs
– Implementation Risk: Low
– Technology/Market Risk: High
– Solicitation Type: Public/Private partnership catalyzed with CEC

B2. System operator DER information needs assessment – Linkage with DR, Transmission, Renewables, EPAG

– Project Objective: Understand system operators' information needs for determining status, location, etc. of DER devices interconnected to their system. Information required to insure safety and enable system benefits
– Desired Results: Paper study of system operator DER information needs
– Project Investment: Low <$500k (Estimated $200k)
– Timeframe: 6 months
– Leverage:
  – Time: UDCs, CAISO, EPRI
  – Talent: Same as time
  – Treasure: EPRI, E2I
– Additional resources: None
– Implementation Risk: Low
– Technology/Market Risk: Low
– Solicitation Type: Sole source or tech support or tailored collaborative

B3. Options analysis for DER system operator information needs – Linkage with DR, Transmission, Renewables, EPAG

– Project Objective: Understand technology options to satisfy system operators' information needs
– Desired Results: Report that determines the most cost-effective and preferred options for meeting system operators' information needs
– Project Investment: Low <$500k (Estimated $200k)
– Timeframe: 6 months
– Leverage:
  – Time: UDCs, CAISO, EPRI
  – Talent: Same as time
  – Treasure: EPRI, E2I
– Additional resources: None
– Implementation Risk: Low
– Technology/Market Risk: Low
– Solicitation Type: Sole source or tech support or tailored collaborative

C1. Demonstrate adaptive feeder protection and coordination – Linkage with DR, Transmission programs

– The paper study and computer simulation part of this project has been initiated by Energy Innovations Small Grants Program

C2. Demonstrate different information monitoring systems for system operators – Linkage with DR, Transmission, Renewables, EPAG

– Project Objective: Demonstrate and evaluate the technical and economical feasibility of different information monitoring systems for system operators to keep track of the operating status of DER
– Desired Results: Validation of the cost-benefit analysis of information monitoring systems
– Project Investment: Medium ($3MM)
– Timeframe: 18 months
– Leverage:
  – Time: UDCs, CAISO, EPRI
  – Talent: Same as time, ALSTOM ESCA, APX, Siemens, Engage Networks, Sixth Dimension, Encorp
  – Treasure: EPRI, DOE
– Additional resources: None
– Implementation Risk: Medium
– Technology/Market Risk: Medium
– Solicitation Type: Sole source or solicitation

D1. Determine what the interconnection cost for DER should be – Linkage with EPAG program

– Project Objective: Understand what is a reasonable hardware costs for interconnection to provide guidance to technology development program for setting program goals and policy direction.
– Desired Results: Targeted interconnection costs by size and application. Cost build-up to identify opportunities for reduction. Understanding of the impact of reduced technology costs on the market.
– Project Investment: $300,000
– Timeframe: 6 months
– Leverage:
  – Time: Interconnection suppliers (ASCO, GE Zenith, Encorp), Rule 21, UDCs, project developers
  – Talent: Same as time
  – Treasure: DOE-DER, E2I
– Additional resources: None
– Implementation Risk: Medium
– Technology/Market Risk: Medium
– Solicitation Type: Competitive solicitation or sole sources

D3. Power electronics E.G. inverters (improved reliability) – Linkage with Renewables program

– Project Objective: Improve reliability and reduce costs of power electronics (from Microgrid workshop)
  • Power Electronics – reduce costs and improve reliability in all kW ranges, heat management, manufacturability, modularity, standardization, component count reduction, tech transfer benefit from automotive, determine performance requirements rather than design for unknown, reliability models and testing
  • Energy Storage – reduce costs, improve reliability and extend life
– Desired Results: Reduced costs and performance of power electronics
– Project Investment:
  – Phase I: Scoping study - $200k (majority of work completed with cost share from DOE and CERTS)
  – Phase II: Conceptual Engineering - $1MM
  – Phase III: Bench and Lab testing - $1MM
– Timeframe: Phase I (4-6 months assuming we can leverage what DOE has already done), Phase II (9 months to 1year), Phase III (9 months to 1 year)
– Leverage:
  – Time: DOE-NREL
  – Talent: Xantrex, Capstone, SatCon, Northern Power Systems
  – Treasure: DOE-NREL
– Additional resources: EPAG, Renewables
– Implementation Risk: Low
– Technology/Market Risk: Medium/High
– Solicitation Type: Competitive solicitation in partnership with DOE-NREL

E1. Combined DR-DER price signal software - Linkage with DR program

- Project Objective: Develop adaptive software for DER/DR that includes modules for DR/DER units, retail price signals, wholesale price signals
- Desired Results: Demonstrated software that optimizes DER/DR in response to variety of price signals. This software could be easily adapted to accommodate different price signal sources.
- Project Investment: Phase I – Scoping Study to understand where CEC should invest ($100k), Phase II – Software Development ($500k), Phase III – Testing and Demonstration ($500K)
- Timeframe: Phase I (3months), Phase II (1 year), Phase III (18 months)
- Leverage:
  - Time: Peak Load Management Association, Software companies
  - Talent: Software companies (Silicon Energy, Sixth Dimension)
  - Treasure: DOE
- Additional resources: DR program
- Implementation Risk: Low
- Technology/Market Risk: Medium
- Solicitation Type: Competitive

G2. Test DG as enabler for DR (and vice versa) – Linkage with DR program

- Project Objective: Understand the synergies between DG and DR and implications for market opportunity
- Desired Results: Paper study that identifies and quantifies how DG can further enable and grow DR and vice versa
- Project Investment: $300k
- Timeframe: 12 months
- Leverage:
  - Time: CPA, CAISO
  - Talent: ISOs (NE, NY, PJM), e3
  - Treasure: E2I, DOE
- Additional resources: DR program
- Implementation Risk: Low
- Technology/Market Risk: Low
- Solicitation Type: Solicitation

G3. a) Solicit field demonstration of DER value network Green Power

- Project Objective: Analyze and determine what the value chain would be and a market mechanisms for delivering that value to the appropriate market segment. Next step would be to create a demonstration program to affect that value network.
- Desired Results: Analysis and pilot implementation of a cost-effective value network resulting in recommendations for a market launch
- Project Investment: Phase I – Design Value Network ($800k), Phase II – Demonstration and evaluation of Value Network ($10-100MM total with CEC funding evaluation part for $2MM)
- Timeframe: Phase I (18 months), Phase II (2.5 years)
- Leverage:
  - Time: OEMs, UDCs, developers, marketers, system operators, CPUC, CPA
  - Talent: Same as time, ISONE contractor for green power market
  - Treasure: CPA, DOE, E2I
- Additional resources: Renewables, PIER Renewables and Commissioners
- Implementation Risk: Phase I – Low, Phase II - High
- Technology/Market Risk: Phase I – Low, Phase II - High
- Solicitation Type: Phase I – Solicitation; Phase II - TBD

G3. b) Solicit field demonstration of DER value network Energy Supply and Delivery

- Project Objective: Analyze and determine what the value chain would be and a market mechanisms for delivering that value to the appropriate market segment. Next step would be to create a demonstration program to affect that value network.
- Desired Results: Analysis and pilot implementation of a cost-effective value network resulting in recommendations for a market launch
- Project Investment: Phase I – Design Value Network ($800k), Phase II – Demonstration and evaluation of Value Network ($10-100MM total with CEC funding evaluation part for $2MM)
- Timeframe: Phase I (18 months), Phase II (2.5 years)
- Leverage:
  - Time: OEMs, UDCs, developers, marketers, system operators, CPUC, CPA, EPRI
  - Talent: Same as time, ISOs (NY, NE and PJM)
  - Treasure: CPA, DOE, EPRI, E2I
- Additional resources: CEC Integrated Planning team?
- Implementation Risk: Phase I – Medium, Phase II - High
- Technology/Market Risk: Phase I – Medium, Phase II - High
- Solicitation Type: Phase I – Solicitation; Phase II - TBD

G3. c) Solicit field demonstration of DER value network DER Exchange

- Project Objective: Analyze and determine what the value chain would be and a market mechanisms for delivering that value to the appropriate market segment. Next step would be to create a demonstration program to affect that value network.
- Desired Results: Analysis and pilot implementation of a cost-effective value network resulting in recommendations for a market launch
- Project Investment: Phase I – Design Value Network ($800k), Phase II – Demonstration and evaluation of Value Network ($10-100MM total with CEC funding evaluation part for $2MM)
- Timeframe: Phase I (18 months), Phase II (2.5 years)
- Leverage:
  - Time: OEMs, UDCs, developers, marketers, system operators, CPUC, CPA, EPRI
  - Talent: Same as time, ISOs (NY, NE and PJM)
  - Treasure: CPA, DOE, EPRI, E2I
- Additional resources: CEC Integrated Planning team?
- Implementation Risk: Phase I – Medium, Phase II - High
- Technology/Market Risk: Phase I – Medium, Phase II - High
- Solicitation Type: Phase I – Solicitation; Phase II - TBD

H1. Effect of CARB rules on technology choice and development – Linkage with EPAG, Environmental programs

- Project Objective: Understand the impact that environmental regulations on R&D investments to improve the environmental performance of gas engines, gas turbines or microturbines.
- Desired Results: A critical analysis of how environmental regulations drive public and private R&D investments for gas engines, gas turbines and microturbines. Determine if these regulations encourage or discourage investment or innovation.
- Project Investment: $200k
- Timeframe: 6 months
- Leverage:
  - Time: USCHPA, NRDC, CARB, OEMs
  - Talent: Same as time
  - Treasure: DOE, EPA-CHP Challenge
- Additional resources: Environmental, EPAG
- Implementation Risk: Low
- Technology/Market Risk: Medium
- Solicitation Type: Solicitation or sole source

H2. Environmental dispatch – Linkage with EPAG, Environmental programs

- Project Objective: Identify the optimal environment and economical dispatch strategies for DER
- Desired Results: Case studies of dispatch of DER compared to rolling blackout episodes in 2001
- Project Investment: Small ($300k)
- Timeframe: 9 months
- Leverage:
  - Time: CPA, CARB
  - Talent: Same as time
  - Treasure: EPA-CHP Challenge, DOE-DER
- Additional resources: Environmental, EPAG
- Implementation Risk: Low
- Technology/Market Risk: Medium
- Solicitation Type: Solicitation or sole source

Figure 31. Proposed Projects

6.0 Evaluation of Projects

6.1. Metrics Tool Design

The Value Metrics Tool was developed to further complement the DER Integration Research Program's previous decision-making process by allowing program managers to better evaluate project proposals. It allows the Program Advisory Committee, comprised of external DER research stakeholders, to make portfolio recommendations considering the value generated by each project. The tool identifies the candidate projects that generate the most value while providing more structure to RFPs and proposal evaluation. Additionally, the Value Metrics Tool assesses the impact of external (e.g., regulatory, market and technology) and internal (e.g., budget) changes.

Characteristics to be measured by the Value Metrics Tool were based on the objectives of the DER Integration Research Program (Figure 32).

<table>
<tr><th rowspan="2" colspan="3"></th><th colspan="4">Key ESI DER Objectives</th></tr>
<tr><th>Cleaner, Safer, Cheaper and more Reliable</th><th>Systems Issues</th><th>Appropriate for Public Funding</th><th>Remove Technical Barriers</th></tr>
<tr><th rowspan="18">Measurement Areas and Metrics</th><th>Area</th><th>Metric</th><th></th><th></th><th></th><th></th></tr>
<tr><td rowspan="7">Strategic Fit</td><td>Goal of cleaner energy</td><td rowspan="7">√</td><td rowspan="7">√</td><td rowspan="7">√</td><td rowspan="7"></td></tr>
<tr><td>Goal of safer energy</td></tr>
<tr><td>Goal of reliable energy</td></tr>
<tr><td>Goal of quality energy</td></tr>
<tr><td>Goal of cheaper energy</td></tr>
<tr><td>Multiple PIER programs</td></tr>
<tr><td>Size of gap</td></tr>
<tr><td rowspan="8">Impact to Consumers</td><td>Size of Opportunity</td><td rowspan="8">√</td><td rowspan="8">√</td><td rowspan="8"></td><td rowspan="8">√</td></tr>
<tr><td>Cost Reduction</td></tr>
<tr><td>Industry-wide investment</td></tr>
<tr><td>Expert hunch</td></tr>
<tr><td>Air emissions</td></tr>
<tr><td>Greenhouse emissions</td></tr>
<tr><td>Solid / Liquid emissions</td></tr>
<tr><td>Severe accidents</td></tr>
<tr><td rowspan="2">Risk</td><td>Technology</td><td rowspan="2">√</td><td rowspan="2"></td><td rowspan="2">√</td><td rowspan="2">√</td></tr>
<tr><td>Project Management</td></tr>
</table>

Figure 32. Metrics Identification

A scale and guideline was developed for key metrics that allowed for greater consistency in evaluating projects (Figure 33).

Example

Measurement Area	Candidate Metric	1	2	3	4	5	Guidelines
Strategic Fit	Project has goal of making energy **cheaper**	Could have an adverse impact	Will not have an impact	Will have an indirect positive impact	It is a secondary goal of the project	It is a key goal of the project	• Making energy cheaper considers reducing any of the costs associated with the permitting, generation, transmission, distribution, interconnection, consumption and any other activity related to electricity. • A key goal is considered when it is stated or sufficiently illustrated in the project description, statement or objective. • A secondary goal is when it is included in the project definition under the section “describe how this project supports the objectives of PIER” or when it is sufficiently illustrated in the project description, statement or objective.

Measurement Area	Candidate Metric	1	2	3	4	5	Guidelines
Impact to Consumers	Potential **reductions in cost**	Cost increase	Zero impact on cost	1% to 10%	10% to 25%	Above 25%	• This measure is related to the size of opportunity measure. This one will state how much of that opportunity can be captured through this project (e.g., the interconnection standards will reduce interconnection costs by 30%). • Each project is evaluated for what it will accomplish by itself. • Each project is evaluated in terms of the value potential it has, independent of other projects that are overlapping or that could achieve the same objective.

Figure 33. Illustrative Metric Design

Each project was evaluated against a metrics scorecard to determine its overall score. The Distributed Utility Integration Test is highlighted for illustrative purposes in Figure 34.

Example

Project 3: Distributed utility integration test –DUIT						
Area	**Metric**	**Score**	**Weight**	**Rationale**	**Area Score**	**Weight**
Strategic Fit	Goal of cleaner energy	2	15%	No impact	3.8	40%
	Goal of safer energy	4	10%	Indirect positive impact through safer interconnection		
	Goal of reliable energy	5	15%	Key objective of interconnection is higher reliability		
	Goal of quality energy	4	10%	Key objective of interconnection is higher quality		
	Goal of cheaper energy	4	15%	Large Size of Opportunity DER interconnections would create economic benefits		
	Multiple PIER programs	2	15%	Collaborating with EPAG		
	Size of gap	5	20%	Significant gap		
Impact to Consumers	Size of Opportunity	2	20%	While permitting large numbers of DER into system is very important, the interconnection cost itself is low	3	40%
	Cost Reduction	4	20%	Demonstration will allow to understand how to carry out large scale interconnections (large penetration)		
	Industry-wide investment	3	15%	Large scale implementations would require a medium investment on interconnection equipment and tools		
	Expert hunch	4	20%	Critical to wide adoption of DER		
	Air emissions	2	10%	Not expected to have a significant impact		
	Greenhouse emissions	2	5%	Not expected to have a significant impact		
	Solid / Liquid emissions	2	5%	Not expected to have a significant impact		
	Severe accidents	2	5%	Not expected to have a significant impact		
Risk	Technology	3	67%	Medium risk level	3	20%
	Project Management	3	33%	Medium risk level		
				Overall Value Score (1 - 5)	**3.3**	

Figure 34. Illustrative Metrics Scorecard

6.2. Assessment of Current Projects

The Value Metric Tool was applied to current projects, which were generally quite valuable and well aligned with the CEC's DG Strategic Plan. The data obtained and the resulting plots (Figure 35 and Figure 36) are valuable inputs for portfolio analysis efforts going forward.

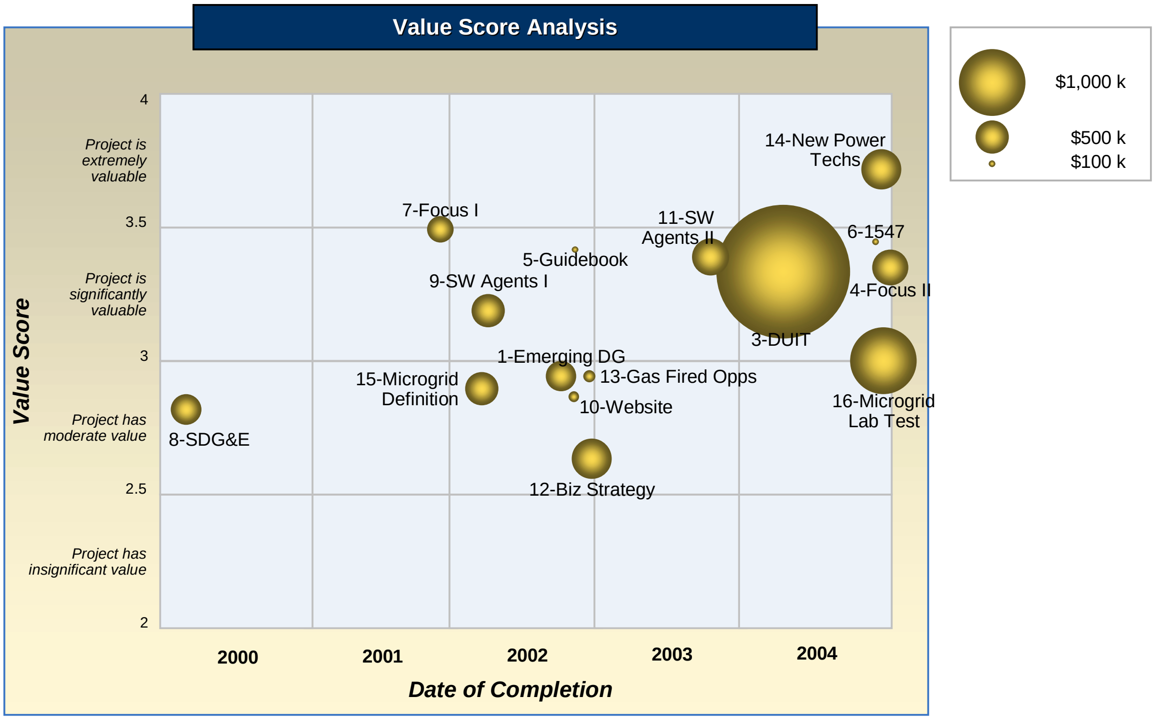

Figure 35. Value Score of Current Projects

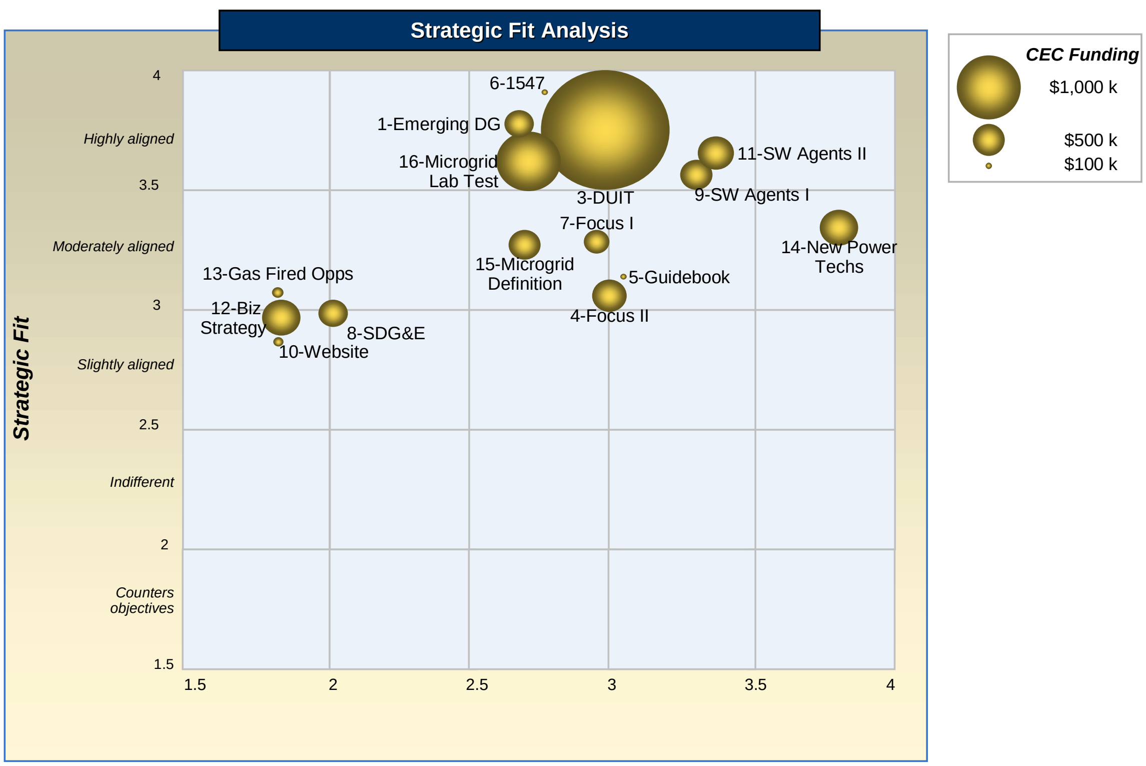

Figure 36. Strategic Fit of Current Projects

6.3. Assessment of Proposed Projects

The Value Metrics Tool was also applied to 21 of the 23 proposed projects that addressed the highest priority research initiatives (Figure 37). The projects generally had mid to moderately high value scores.

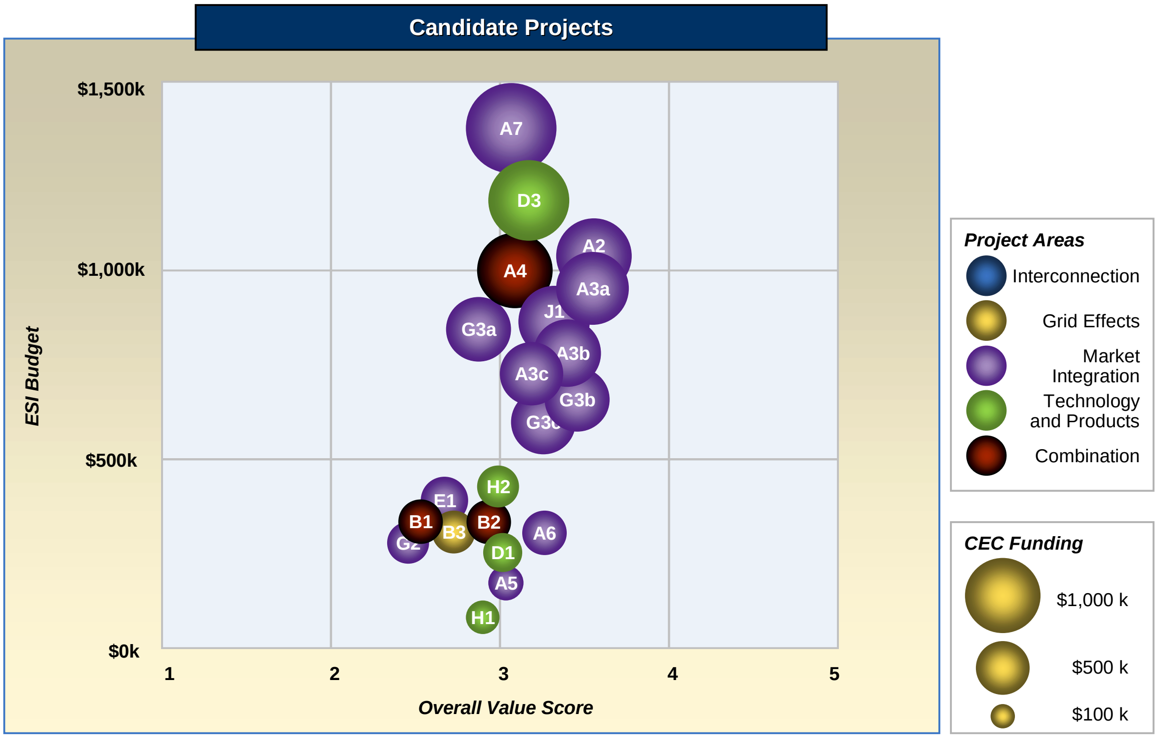

Figure 37. Value Score of Proposed Projects

Note: The details of the projects denoted by alphanumeric reference codes in the above figure are available in Figure 38.

7.0 Project Portfolio Analysis

7.1. Portfolio Analysis Overview

Developing a project portfolio that balances the many goals of the DER Integration Research Program given an environment with uncertain funding can be a significant challenge. To help address this concern, portfolio analysis plotting tools were introduced where projects can be visually presented on axes displaying metrics and characteristics. Portfolios assuming budgets of approximately $13 million, $10 million and $5 million were analyzed in detail.

In the plot below (Figure 38), candidate projects and existing projects are plotted against competitive impact and project timeframe. This visual tool provides a snapshot of projects that allows program managers to evaluate whether or not appropriate balance is being maintained against the critical project characteristics as new projects are added or taken away. To create the $13 million, $10 million, and $5 million portfolios, such plotting tools were used extensively to aid in the screening of the candidate projects.

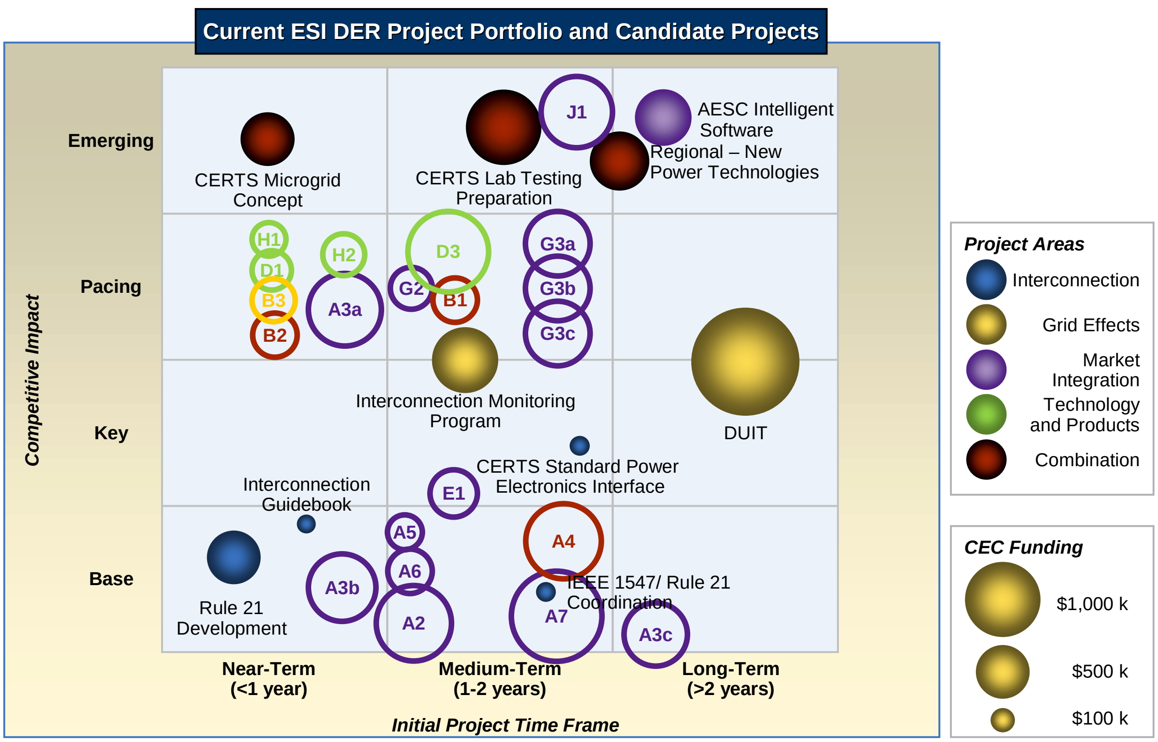

Figure 38. Competitive Impact x Initial Project Time Frame Plot

Note: The details of the projects denoted by alphanumeric reference codes in the above figure are available in Figure 39.

For current projects, please refer to Figure 29.

7.2. $13, $10 and $5 Million Budget Portfolios

Using the portfolio analysis tools, the potential $13 million portfolio containing 21 highest priority projects (Figure 39) was created and is described below.

Description of $13 Million Budget Candidate Projects
J1. Integrate AESC technology into field demonstration
A2. Paper study to quantify value of DER and develop common metrics – Linkage with Renewables, Buildings programs
A3. a) Develop (if necessary) and implement tools to determine value of DER to a particular regional problem –Link Regional
A3. b) Understand technical options and develop price signals (tariffs, incentives) to elicit regional response–Link Regional
A3. c) Demonstrate and evaluate regional solutions
A4. Understand effect of DG on environmental (addressing central system complexity) – Linkage with Environmental
A5. Develop business case for utility DER – Linkage with DR program
A6. Economic analysis on utility DER ownership / market power – Linkage with CSEM UC Berkeley program
A7. Aggregated Distributed Generation Pilot Program – Linkage with CAISO, DR programs
B1. Develop Command, Control and Communications Integration plan (C^3I Plan) – Linkage with DR, Transmission
B2. System operator DER information needs assessment – Linkage with DR, Transmission, Renewables, EPAG
B3. Options analysis for DER system operator information needs – Linkage with DR, Transmission, Renewables, EPAG
D1. Determine what the interconnection cost for DER should be – Linkage with EPAG program
D3. Power electronics E.G. inverters (improved reliability) – Linkage with Renewables program
E1. Combined DR-DER price signal software - Linkage with DR program
G2. Test DG as enabler for DR (and vice versa) – Linkage with DR program
G3. a) Solicit field demonstration of DER value network Green Power
G3. b) Solicit field demonstration of DER value network Energy Supply and Delivery
G3. c) Solicit field demonstration of DER value network DER Exchange
H1. Effect of CARB rules on technology choice and development – Linkage with EPAG, Environmental programs
H2. Environmental/Economic dispatch strategies – Linkage with EPAG, Environmental programs

Figure 39. $13 Million Portfolio

Each candidate project was characterized according to the criteria used to analyze the portfolio (Figure 40). The criteria used to analyze the portfolio can vary depending on the constraints and needs of the Program at that moment in time.

Candidate Project	Estimated CEC Funds	Project Timeframe	Entire Project Timeframe	Implementation Risk	Technology / Market Risk	Solicitation Type	Systems Issue	Development Stage	Competitive Impact	Time to Impact
J1	$ 875	18	18	L	H	SS	MI	Demonstration	Emerging	M
A2	$ 1,000	12	36	L	M	G,CS	MI	Research	Base	NT
A3 a	$ 900	9	9	L	M	CS	MI	Dev/Dem	Pacing	M
A3 b	$ 800	9	9	L	M/H	SS,CS	MI	Dev/Dem	Base	M
A3 c	$ 700	24	24	M/H	M/H	SS,CS	MI	Demonstration	Base	M
A4	$ 1,000	18	18	M	M	CS	MI, T&P	Research	Base	NT
A5	$ 210	12	12	M	H	TS	MI	Research	Base	NT
A6	$ 350	12	12	L	L/M	SS	MI	Research	Base	NT
A7	$ 1,400	18	18	H	M	SS,G	MI	Demonstration	Base	NT
B1	$ 350	15	15	L	H	PPP, SS, CS	GE, MI	Research	Pacing	M
B2	$ 350	6	6	L	L	SS, TS	GE, MI	Research	Pacing	NT
B3	$ 315	6	6	L	L	SS, TS	GE	Research	Pacing	NT
D1	$ 270	6	6	M	M	SS, CS	T&P	Research	Pacing	M
D3	$ 1,125	15	27	L	M/H	CS	T&P	Development	Pacing	M
E1	$ 390	15	33	L	M	CS	MI	Development	Pacing	NT
G2	$ 300	12	12	L	L	CS	MI	Dev/Dem	Pacing	NT
G3 a	$ 720	18	48	M	M	CS	MI	Demonstration	Pacing	M
G3 b	$ 720	18	48	M	M	CS	MI	Demonstration	Pacing	M
G3 c	$ 720	18	48	M	M	CS	MI	Demonstration	Pacing	M
H1	$ 200	6	6	L	M	SS, CS	T&P	Research	Pacing	NT
H2	300	9	9	L	M	SS, CS	T&P	Research	Pacing	NT
21 Projects	*$ 12,995*									

Notes: Funds in thousands of dollars
Timeframe numbers are in months
Scale (H-High, M-Medium, L-Low)
System Issues (MI-Market Integration, GE-Grid Effects, I-Interconnection, T&P-Technology and Products
Solicitation Type (SS-Sole Source, G-Grant, CS-Competitive Solicitation, TS-Technical Support, PPP-Private/Public Partnership)
Time to Impact (Near-term - <5 years, Mid-term - 5-15 years, Long-term - >15years)

Figure 40. $13 Million Portfolio Characterization

Relative to the $13 million budget scenario, here are some observations on how a portfolio with a $10 million budget limit may differ. Grid Effects projects are eliminated. To align the portfolio with the roadmap, projects B1, H1, and H2 are removed. There is now a significant bias toward Market Integration projects. Many Pacing projects on the Competitive Impact scale and Research projects on the Development Stage scale are dropped. Many short projects with low implementation risk, lower value and smaller scale are also eliminated. The $10 million portfolio is described below (Figure 41).

Description of $10 Million Budget Candidate Projects
J1. Integrate AESC technology into field demonstration
A2. Paper study to quantify value of DER and develop common metrics – Linkage with Renewables, Buildings programs
A3. a) Develop (if necessary) and implement tools to determine value of DER to a particular regional problem –Link Regional
A3. b) Understand technical options and develop price signals (tariffs, incentives) to elicit regional response–Link Regional
A3. c) Demonstrate and evaluate regional solutions
A4. Understand effect of DG on environmental (addressing central system complexity) – Linkage with Environmental
A5. Develop business case for utility DER – Linkage with DR program
A6. Economic analysis on utility DER ownership / market power – Linkage with CSEM UC Berkeley program
A7. Aggregated Distributed Generation Pilot Program – Linkage with CAISO, DR programs
D1. Determine what the interconnection cost for DER should be – Linkage with EPAG program
D3. Power electronics E.G. inverters (improved reliability) – Linkage with Renewables program
E1. Combined DR-DER price signal software - Linkage with DR program
G3. b) Solicit field demonstration of DER value network Energy Supply and Delivery
G3. c) Solicit field demonstration of DER value network DER Exchange
H1. Effect of CARB rules on technology choice and development – Linkage with EPAG, Environmental programs
H2. Environmental/Economic dispatch strategies – Linkage with EPAG, Environmental programs

Candidate Project	Estimated CEC Funds	Project Timeframe	Entire Project Timeframe	Implementation Risk	Technology / Market Risk	Solicitation Type	Systems Issue	Development Stage	Competitive Impact	Time to Impact
J1	$ 875	18	18	L	H	SS	MI	Demonstration	Emerging	M
A2	$ 1,000	12	36	L	M	G,CS	MI	Research	Base	NT
A3 a	$ 900	9	9	L	M	CS	MI	Dev/Dem	Pacing	M
A3 b	$ 800	9	9	L	M/H	SS,CS	MI	Dev/Dem	Base	M
A3 c	$ 700	24	24	M/H	M/H	SS,CS	MI	Demonstration	Base	M
A4	$ 1,000	18	18	M	M	CS	MI, T&P	Research	Base	NT
A5	$ 210	12	12	M	H	TS	MI	Research	Base	NT
A6	$ 350	12	12	L	L/M	SS	MI	Research	Base	NT
A7	$ 1,400	18	18	H	M	SS,G	MI	Demonstration	Base	NT
D3	$ 1,125	15	27	L	M/H	CS	T&P	Development	Pacing	M
E1	$ 390	15	33	L	M	CS	MI	Development	Pacing	NT
G3 b	$ 720	18	48	M	M	CS	MI	Demonstration	Pacing	M
G3 c	$ 720	18	48	M	M	CS	MI	Demonstration	Pacing	M
H1	$ 200	6	6	L	M	SS, CS	T&P	Research	Pacing	NT
H2	300	9	9	L	M	SS, CS	T&P	Research	Pacing	NT
15 Projects	*$ 10,690*									

Notes: Funds in thousands of dollars
Timeframe numbers are in months
Scale (H-High, M-Medium, L-Low)
System Issues (MI-Market Integration, GE-Grid Effects, I-Interconnection, T&P-Technology and Products
Solicitation Type (SS-Sole Source, G-Grant, CS-Competitive Solicitation, TS-Technical Support, PPP-Private/Public Partnership)
Time to Impact (Near-term - <5 years, Mid-term - 5-15 years, Long-term - >15years)

Figure 41. $10 Million Portfolio and Characterization

Relative to the $13 million budget scenario, here are some observations on how a portfolio with a $5 million budget limit may differ. The portfolio is left with only Market Integration projects. Many of the same roadmap alignment issues here are the same as those that appeared in the $10 million budget portfolio. With many of the projects dropped having their Development Stage characterized as Base, a more desirable balance is achieved between Base and Pacing. Relatively large and relatively small projects are dropped, leaving a narrower project size range of between $350K and $800K. There is a greater emphasis on demonstration projects and most projects would be done via competitive solicitation. The $5 million portfolio also has lower implementation risk projects and loses most of the projects with near-term outputs. The $5 million portfolio is described below (Figure 42).

Description of $5 Million Budget Candidate Projects
J1. Integrate AESC technology into field demonstration
A2. Paper study to quantify value of DER and develop common metrics – Linkage with Renewables, Buildings programs
A3. a) Develop (if necessary) and implement tools to determine value of DER to a particular regional problem –Link Regional
A3. b) Understand technical options and develop price signals (tariffs, incentives) to elicit regional response–Link Regional
A6. Economic analysis on utility DER ownership / market power – Linkage with CSEM UC Berkeley program
G3. b) Solicit field demonstration of DER value network Energy Supply and Delivery
G3. c) Solicit field demonstration of DER value network DER Exchange

Candidate Project	Estimated CEC Funds	Project Timeframe	Entire Project Timeframe	Implementation Risk	Technology / Market Risk	Solicitation Type	Systems Issue	Development Stage	Competitive Impact	Time to Impact
J1	$ 875	18	18	L	H	SS	MI	Demonstration	Emerging	M
A2	$ 1,000	12	36	L	M	G,CS	MI	Research	Base	NT
A3 a	$ 900	9	9	L	M	CS	MI	Dev/Dem	Pacing	M
A3 b	$ 800	9	9	L	M/H	SS,CS	MI	Dev/Dem	Base	M
A6	$ 350	12	12	L	L/M	SS	MI	Research	Base	NT
G3 b	$ 720	18	48	M	M	CS	MI	Demonstration	Pacing	M
G3 c	$ 720	18	48	M	M	CS	MI	Demonstration	Pacing	M
7 Projects	*$ 5,365*									

Notes: Funds in thousands of dollars
Timeframe numbers are in months
Scale (H-High, M-Medium, L-Low)
System Issues (MI-Market Integration, GE-Grid Effects, I-Interconnection, T&P-Technology and Products
Solicitation Type (SS-Sole Source, G-Grant, CS-Competitive Solicitation, TS-Technical Support, PPP-Private/Public Partnership)
Time to Impact (Near-term - <5 years, Mid-term - 5-15 years, Long-term - >15years)

Figure 42. $5 Million Portfolio and Characterization

8.0 Roadmap

The R&D roadmap (Figure 43) offers a more concrete pathway toward achieving the vision outlined in the California Energy Commission's Distributed Generation Strategic Plan. Careful thought was given to the expected schedule of activities and the timing of outside events that would have an impact on the different focus areas. The roadmap balances these complex factors and plots out a course for short, medium, and long-term action in order to reach the vision for DG in 2020.

The current and planned projects are mapped against the roadmap to ensure that momentum is maintained to move toward the vision laid out by the Distributed Generation Strategic Plan (Figure 44).

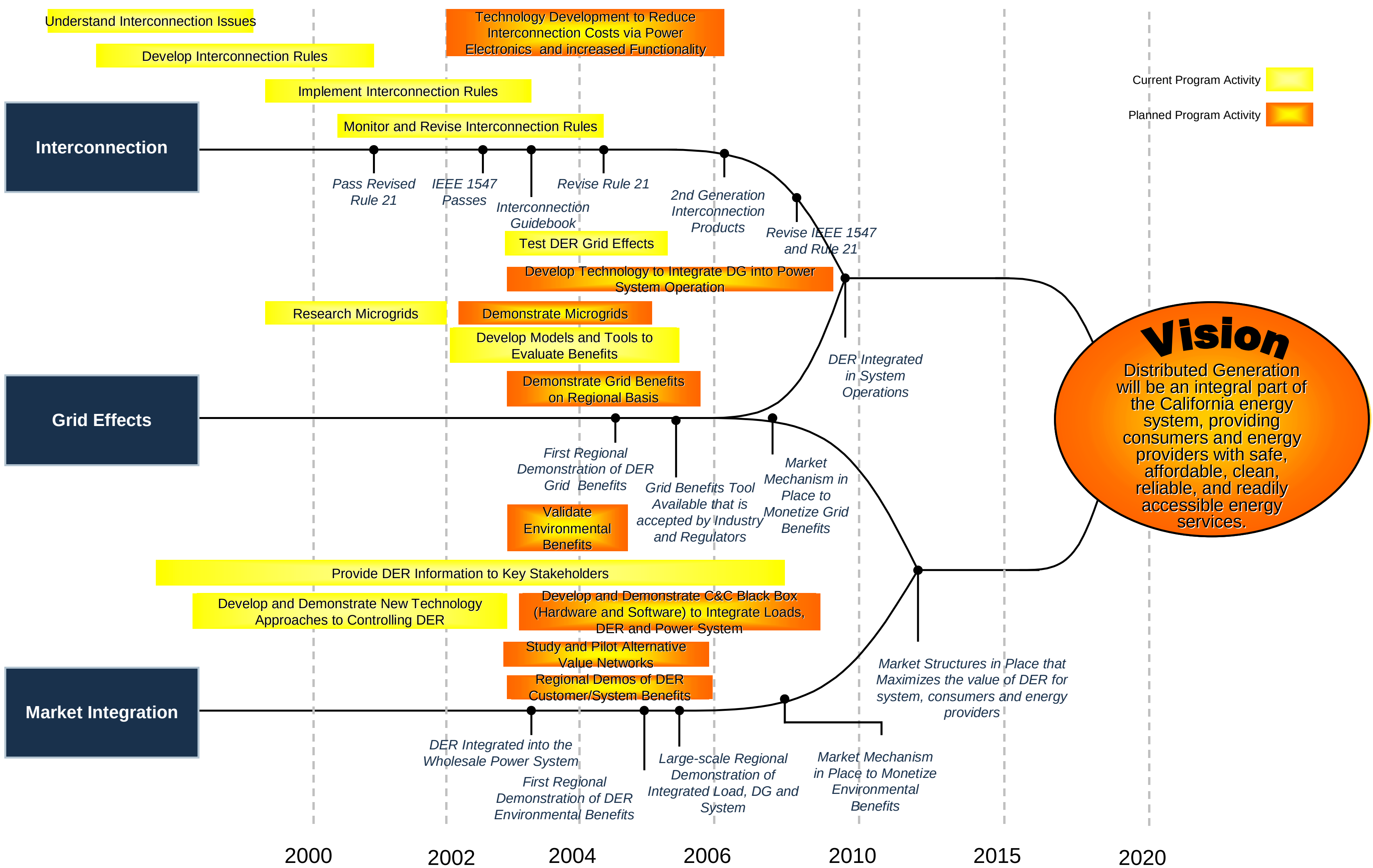

Figure 43. R&D Roadmap

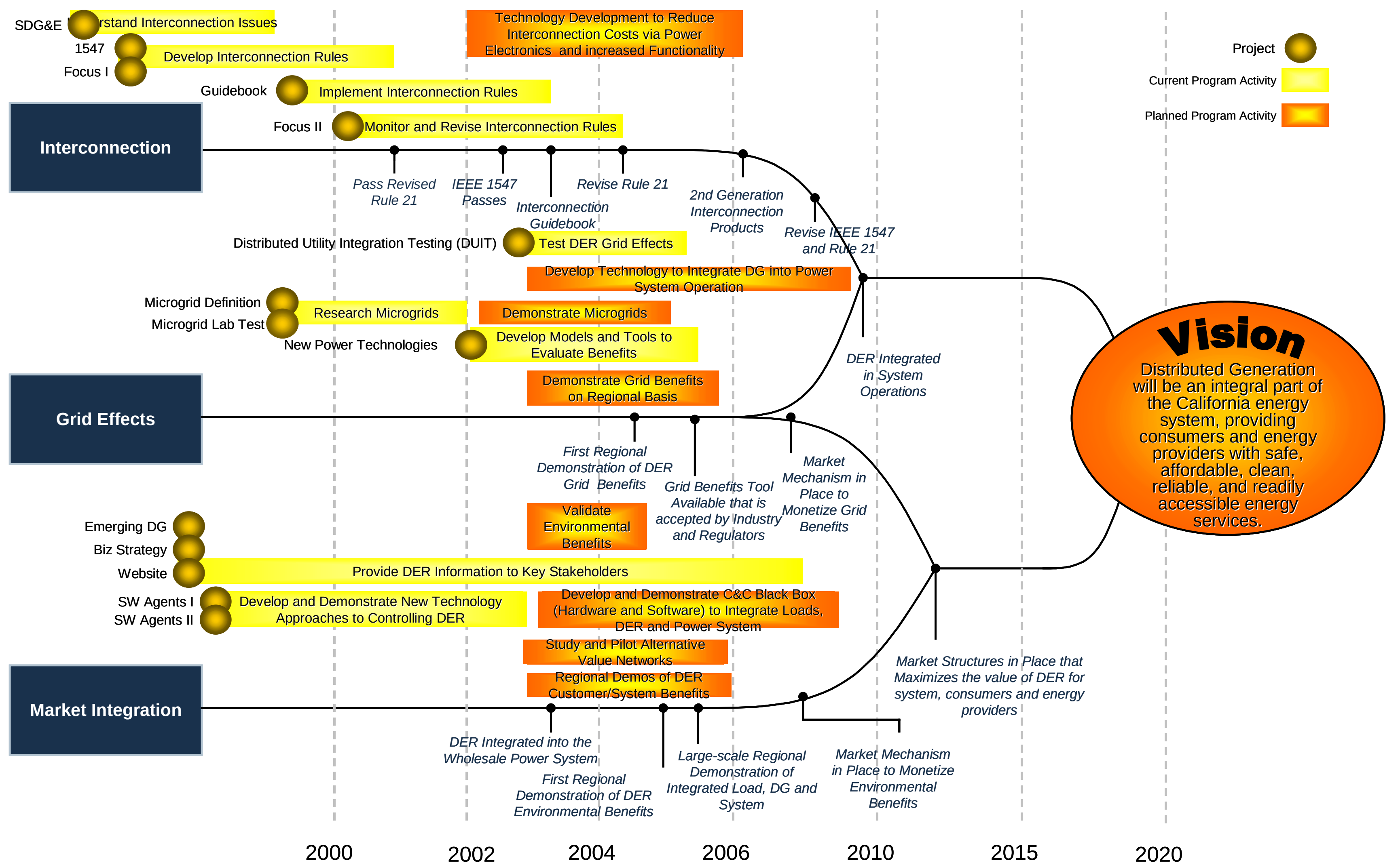

Figure 44. Current Schedule and Projects Applied to Roadmap

9.0 External Linkages

9.1. Partnerships

The DER Integration Research Program works closely with other PIER programs where there is overlapping interest in DER. Partners within CEC PIER include the Environmental, Demand Response, and Transmission programs. Co-funding activities relevant across PIER programs has proven to be an effective way to maximize the benefit and learning given the resource constraints inherent to any research program.

Externally, the DER Integration Research Program has developed a close working relationship with the U.S. Department of Energy (DOE) Distributed Energy and Energy Reliability Program (Figure 45). Co-funding of microgrid research is already taking place through the Consortium for Electric Reliability Technology Solutions (CERTS), a jointly sponsored effort between DOE and the CEC. Plans for Program co-funding of DOE projects conducted at the National Renewable Energy Lab (NREL) are also being developed.

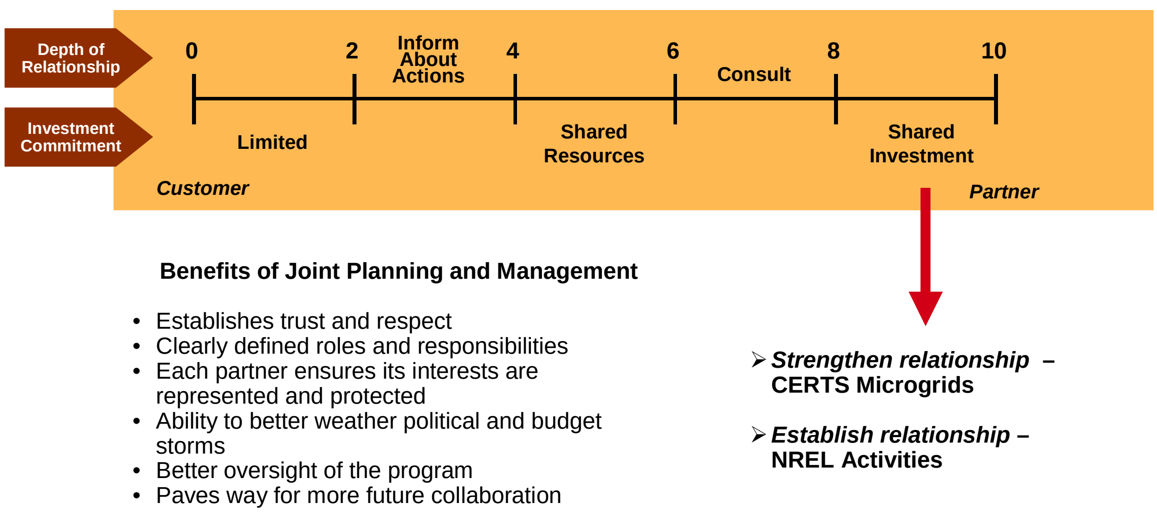

Figure 45. Desired Depth of DOE-CEC Collaboration in DER

Ultimately, there is the desire to selectively develop partnerships and collaborative programs with other outside entities, in both the public and private sectors. Not all of these relationships will necessarily be as deep as those being established with DOE, but they will certainly provide the Program and the collaborative entities with opportunities for information exchange and sharing perspectives on industry challenges. These opportunities are being identified with the help of the DER Integration Research Program Advisory Committee.

9.2. Program Advisory Committee

The Program Advisory Committee (PAC) was established to provide guidance to the DER Integration Research Program to help make the Program a success. Success here is defined as a focused, cohesive, effective program that is aligned with the PIER Program's goals and ultimately provides benefits to California electricity ratepayers. The DER Integration Research

Program manager serves as the coordinator of the Program Advisory Committee and its key point of contact.

9.3. Role of the Program Advisory Committee

The advisory committee is tasked with providing critical reviews of the Program and projects, extend the reach of the Program with the members' expertise and network, and market the Program through increased public visibility. Critical reviews of the DER Integration Research Program and projects involve assessing the Program's progress relative to its intended objectives and the subsequent appropriateness of the current portfolio of projects. The committee enhances current projects by providing direction and feedback as well as identifying linkages with other activities, both internal and external to the CEC. The PAC acts as an extension of the Program by tapping into the members' expertise and network. Brainstorming for projects addressing new needs, innovative approaches to technical issues and project implementation, and leveraging existing work and other resources is a regular committee exercise. The group can provide linkages and communications to efforts throughout the DER stakeholder community, forming the base of an effective marketing platform for the Program.

9.4. Responsibilities of the Program Advisory Committee and Committee Members

PAC members have significant responsibilities to their stakeholders as well as to the committee itself. Members must represent and communicate needs of their particular DER stakeholder group and are expected to be unbiased and represent what is in the best interest of their stakeholder group rather than that of their own companies or organizations. Committee members are not allowed to participate on DER Integration Research Program projects during their tenure and for one year following their tenure. Members provide critical input and support for the Program and DER development in California. Membership requires a one-year commitment during which time members are expected to attend and actively participate in the quarterly meetings.

9.5. Composition of 2002-2003 Program Advisory Committee

The 2002-2003 DER Integration Research Program Advisory Committee members were selected based on their diverse backgrounds and ability to represent different stakeholder perspectives toward the work undertaken by the Program. The six members of the advisory committee are listed below.

- Scott Castelaz - Encorp
- Thomas Dossey - Southern California Edison
- Patricia Hoffman - U.S. Department of Energy
- Thomas Hunton - ASE Americas
- G. Rodney Sluyter – Verizon (retired), RS Consulting
- Valerie Beck – California Public Utility Commission (joined June 3, 2003)

9.6. Overview of 2002-2003 Program Advisory Committee Activities

Three meetings and two conference calls were held over the course of the 2002-2003 term for the DER Integration Research Program Advisory Committee. The meetings provided a forum for committee members to share their insights and opinions through structured discussions that covered topics ranging from Program project portfolio considerations to opportunities for collaborating with outside organizations. Conference calls between the meetings served to enhance communication by allowing the Program's manager to provide the committee with updates of program activities and the committee members to exchange news and developments that may impact the Program.

9.7. Findings and Recommendations

Throughout the year, the PAC provided input into the appropriate scope and focus of the DER Integration Research Program. The Committee expressed that the Program should have an active marketing program. In addition, the Committee suggested the Program consider a role in the area of Economic Development and helped examine that potential role. The Advisory Committee provided input to the Program Manager on the Program's portfolio, roadmap and on individual projects. The Committee provided guidance on the Program's portfolio in two ways; direct input on the project portfolio and through a portfolio balancing exercise. The Program's Roadmap was also reviewed and input was provided to the Program Manager on the Rule 21 project. The Advisory Committee regularly pointed out the importance of having shorter-term projects that provide demonstrable outputs in the near-term to balance out the medium and long-term projects that take a year or more to provide any meaningful output.

The Program Advisory Committee provided guidance throughout the year to the DER Integration Research Program on partnering including prioritizing partnerships and mechanisms for partnering. The PAC also participated in a formal exercise to identify and prioritize partners, and structuring these partnerships. There is strong support for establishing meaningful working relationships with a variety of public and private sector stakeholders with varying levels of interaction. Committee members regularly pointed out areas where there is ongoing activity and the parties with whom the Program should establish contact in order to avoid potentially wasteful overlapping activity.

The Program could be faced with severe crisis over the next two years that could provide both challenges and opportunities. The Program Advisory Committee participated in two scenario exercises to assist the Program Manager in preparing for these crises. Recommendations include developing contingency plans that can serve as a guide as challenges arise and increasing the visibility of program activities and partnerships.

Feedback received from the advisory committee has been continuously transferred into the activities of the DER Integration Research Program, providing valuable inputs that further strengthen the ability of the Program to support groundbreaking work that advances the industry to benefit all Californians.

10.0 Plans for Implementation

10.1. Budget Allocation

In the spring of 2003, the California Energy Commission allocated $7 million for the DER Integration Research Program to pursue research, development and demonstration (RD&D) deemed to be of the highest priority in the 2003-2004 fiscal year. These projects will be conducted in collaboration with the PIER Environmental, PIER Demand Response, and PIER Transmission programs as well as the U.S. Department of Energy. Applying project concepts, metrics and portfolio tools presented in sections 5, 6 and 7, respectively, the DER Integration Research Program will be implementing projects pursuing the initiatives described in **Error! Reference source not found.**.

Initiative	*DERI Core Budget Request (Millions)*	*Timeframe (Months)*	*Partners*
Market Design and Integration Projects	$ 1.2	12-24	PIER EA Demand Response NREL
Regional Grid Benefit Validation Demonstrations	$ 2.0	9-24	Demand Response Transmission Buildings
Interconnection Equipment and Installation Cost Reduction	$ 0.8	6-24	NREL
Grid Effects/DG Penetration Testing	$ 3.0	18-24	Transmission EPAG NREL
Total Request	$ 7.0		

Figure 46. FY 2003-2004 Funding for DER Integration

10.2. Implementation Activities

Based on the funding allocation above, the specifics of implementing the initiatives are further detailed below.

10.2.1. Market Design and Integration

The DER Integration Research Program will conduct analysis, develop methodologies and market mechanisms to capture and monetize additional DER benefits. Project objectives pursuing this initiative include:

- Develop a methodology that accurately and consistently quantifies DER value. Create common metrics for reliability, T&D benefits, emissions, ancillary services. This would be useful for creating a market structure (e.g., model tariffs, etc) and will be provided to regulators considering these issues.
- Demonstrate feasibility of economically optimizing and aggregating multiple DER devices to respond to simulated market signals
- Conduct cost/benefit assessment of DER compared to central plant system

10.2.2. Regional Grid Benefits Validation Demonstrations

The Program will demonstrate and validate the ability of DER to reliably provide grid benefits to address regional distribution, transmission, and environmental problems. Project objectives pursuing this initiative include:

- Development and implementation of tools for determining value of DER to a particular regional problem
- Understand the technical options and develop price signals to elicit a regional response
- Demonstrate and evaluate regional solutions

10.2.3. Interconnection Equipment and Cost Reduction

The DER Integration Research Program will work to increase the functionality of interconnection equipment and further reduce equipment and installation cost. Project objectives pursuing this initiative include:

- Development of a universal interconnection device with increased functionality and reliability, and reduced cost
- Further streamlining of interconnection rules through development of Supplemental Review Guidelines

10.2.4. Grid Effects/DG Penetration Testing

The Program will work to demonstrate and test varying levels of DER penetration into distribution systems. Project objectives pursuing this initiative include:

- Testing of the penetration levels achievable and electrical impacts of DG devices on distribution system operations and loads
- Real-world monitoring of interconnected DG device to determine interactions between distribution system, on-site loads and DG device
- Laboratory testing of CERTS microgrid concept to determine function feasibility
- Modeling and testing of effects of unbalanced loading with DER on voltage regulation
- Modeling and testing of real world value relative to anti-islanding and interconnection standards

11.0 Closing Comments

Under guidance of California Energy Commission policies for Distributed Energy Resources, over the coming year, the DER Integration Research Program will continue to address relevant technical barriers facing the successful deployment of DER in California. The Program will implement a budget of $7 million in priority research in the areas of interconnection, grid effects, and market integration. The Program will continue to use the portfolio management tools and processes it has developed to ensure the DER Integration Research Program is flexible and responsive to California’s needs.